

MCGINN & GIBB, PLLC
A PROFESSIONAL LIMITED LIABILITY COMPANY
PATENTS, TRADEMARKS, COPYRIGHTS, AND INTELLECTUAL PROPERTY LAW
8321 OLD COURTHOUSE ROAD, SUITE 200
VIENNA, VIRGINIA 22182-3817
TELEPHONE (703) 761-4100
FACSIMILE (703) 761-2375; (703) 761-2376

**APPLICATION
FOR
UNITED STATES
LETTERS PATENT**

APPLICANT'S: NOBUYUKI ENOMOTO, ET AL.

**FOR: NETWORK SYSTEM, LEARNING BRIDGE
NODE, LEARNING METHOD AND ITS
PROGRAM**

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NETWORK SYSTEM, LEARNING BRIDGE NODE, LEARNING METHOD
AND ITS PROGRAM

BACKGROUNDS OF THE INVENTION

5

1. Field of the Invention

The present invention relates to a network system,
and more particularly to a network system, a learning
bridge forming node, a learning bridge forming method
and a program which can make a learning operation of a
10 bidirectional flow passing through an asymmetrical path
and can also learn a forwarding tag to be added so as to
add it when forwarding.

2. Description of the Related Art

Such a type of learning bridge is conventionally
15 used to determine a transfer route for Ethernet and the
like. There are prior arts concerning the learning
bridge as follows.

For example, a standardization document entitled
"1998, IEEE Std. 802.1D" issued by IEEE specifies a
20 method called a learning process which enters a port
having received the frame and a source MAC address (MAC
SA) of the frame in a filtering database so to determine
a transfer destination port of the frame (hereinafter
referred to as the non-patent literature 1).

25 A standardization document entitled "1998, IEEE
Std. 802.1Q" issued by IEEE specifies a method called
Independent Virtual Local Area Network (VLAN) Learning

(IVL) and an IVL bridge for performing the IVL to independently perform the learning process for each VLAN and limits the use of a learned result to an arrival time of a frame belonging to the same VLAN as that of the frame used for learning (hereinafter referred to as the non-patent literature 2).

Besides, a technology concerning a frame transfer method using an expansion tag, a technology concerning a node structure and table structure for adding a control tag and a path determination method using a spanning tree to determine a path according to a forwarding tag are disclosed in, for example, " Proposal of Ethernet Architecture GOE (Global Optical Ethernet) for Future Generation" (Institute of Electronics, Information and Communication Engineers, 2002 Society Meeting's Lecture Papers B-7-11 to B-7-13) (hereinafter referred to as the non-patent literature 3).

The above-described technologies had the following problems.

First, the conventional technologies disclosed in the non-patent literature 1 and the non-patent literature 2 had a problem that a network's bandwidth usability became low.

The technologies of the non-patent literatures 1 and 2 are premised on a symmetrical flow that the bi-directional frame flows a symmetrical path. Therefore, when a node through which a flow passes depending on a

direction allows a different asymmetrical flow as shown in the non-patent literatures 1 to 3, a learning process does not operate, the frame reaches the destination but is also transferred to unnecessary destinations.

5 Therefore, there were problems that the network became busy and the bandwidth usability was reduced.

Second, the prior art described in the non-patent literature 3 also had a problem that the setting operation was troublesome.

10 To use the technology of the non-patent literature 3, it was necessary to previously determine for each node an expansion tag (forwarding tag) to be added according to a destination MAC address (MAC DA), but the determination work involved a lot of time and
15 labor because the number of MAC addresses became several thousands or several tens of thousands depending on the networks.

SUMMARY OF THE INVENTION

20 A first object of the present invention is to provide a network system, a learning bridge forming node, a learning bridge forming method and a program which can improve bandwidth usability for a network flowing an asymmetrical flow.

25 A second object of the present invention is to provide a network system, a learning bridge forming node, a learning bridge forming method and a program which can

automate an operation of setting a forwarding tag to be added.

According to the first aspect of the invention, a network system for a network having plural nodes
5 connected, wherein a node belonging to said network transmit a learning frame periodically to a path opposite to that in which a main signal frame flows.

According to another aspect of the invention, a network system for a network having plural nodes
10 connected, wherein a node belonging to said network is provided with:

a learning frame management unit which refers to a MAC SA table cache to determine whether a learning frame transmission request is made or not, and a MAC SA
15 table cache which stores a source MAC address (MAC SA) which has made a learning frame transmission request.

According to another aspect of the invention, a network system for a network having plural nodes connected, wherein a node belonging to said network is
20 provided with a learning management program which conducts a learning frame process.

According to another aspect of the invention, a network system for a network having plural nodes connected, wherein a node belonging to said network also
25 applies a learning function of Ethernet to a flow which flows asymmetrically.

According to another aspect of the invention, a

learning bridge node for a network having plural nodes connected, wherein a learning frame is transmitted periodically to a path opposite to a path in which a main signal frame flows.

5 According to another aspect of the invention, a learning bridge node of a network having plural nodes connected, comprising a learning frame management unit which refers to a MAC SA table cache to determine whether a learning frame transmission request is made or
10 not, and a MAC SA table cache which stores a source MAC address (MAC SA) which has made a learning frame transmission request.

 According to another aspect of the invention, a learning bridge node for a network having plural nodes
15 connected, comprising a learning management program which performs learning frame processing.

 According to another aspect of the invention, a learning bridge node for a network having plural nodes connected, wherein a learning function of Ethernet is
20 applied to a flow which asymmetrically flows.

 According to another aspect of the invention, a learning method of a network having plural nodes connected, wherein a node belonging to said network transmits a learning frame periodically to a path
25 opposite to that in which a main signal frame flows.

 According to another aspect of the invention, a learning method of a network having plural nodes

connected, wherein a node belonging to said network

refers to a MAC SA table cache to judge whether
or not a learning frame transmission request is made,
and stores a source MAC address (MAC SA) which has made
a learning frame transmission request in said MAC SA
table cache.

According to another aspect of the invention, a
learning method for a network having plural nodes
connected, wherein a node belonging to said network is
provided with a learning management program which
performs learning frame processing.

According to another aspect of the invention, a
learning method for a network having plural nodes
connected, wherein a node belonging to said network also
applies a learning function of Ethernet to a flow which
flows asymmetrically.

Other objects, features and advantages of the
present invention will become clear from the detailed
description given herebelow.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood more
fully from the detailed description given herebelow and
from the accompanying drawings of the preferred
embodiment of the invention, which, however, should not
be taken to be limitative to the invention, but are for
explanation and understanding only.

In the drawings:

Fig. 1 is a block diagram showing a configuration example of a physical network according to a first embodiment of the invention;

5 Fig. 2 is a block diagram showing an Ethernet frame configuration according to the first embodiment of the invention;

10 Fig. 3 is a block diagram showing a VLAN Tagged Ethernet frame configuration according to the first embodiment of the invention;

Fig. 4 is a block diagram showing a VLAN tag configuration according to the first embodiment of the invention;

15 Fig. 5 is a block diagram showing a configuration of Ethernet frame with a forwarding tag according to the first embodiment of the invention;

Fig. 6 is a block diagram showing a tag configuration according to the first embodiment of the invention;

20 Fig. 7 is a block diagram showing a learning frame configuration according to the first embodiment of the invention;

25 Fig. 8 is a block diagram showing a learning frame configuration according to the first embodiment of the invention;

Fig. 9 is a block diagram showing a node G1 configuration in detail according to the first

embodiment of the invention;

Fig. 10 is a block diagram showing in detail a configuration of a packet forwarding unit 20 according to the first embodiment of the invention;

5 Fig. 11 is a block diagram showing in detail a configuration of a frame analyzer 201 according to the first embodiment of the invention;

Fig. 12 is a block diagram showing in detail a configuration of a learning frame transmission
10 management unit 202 according to the first embodiment of the invention;

Fig. 13 is a block diagram showing in detail a configuration of a MACSA table cache 2025 according to the first embodiment of the invention;

15 Fig. 14 is a block diagram showing in detail a configuration of a table search unit 203 according to the first embodiment of the invention;

Fig. 15 is a block diagram showing in detail a configuration of a forwarding table 204 according to the
20 first embodiment of the invention;

Fig. 16 is a block diagram showing in detail a configuration of a MAC forwarding table memory 2043 according to the first embodiment of the invention;

Fig. 17 is a block diagram showing in detail a
25 configuration of a tag forwarding table memory 2041 according to the first embodiment of the invention;

Fig. 18 is a block diagram showing in detail a

configuration of a broadcast table memory 2042 according to the first embodiment of the invention;

Fig. 19 is a block diagram showing in detail a configuration of an aging management table 2044 according to the first embodiment of the invention;

Fig. 20 is a block diagram showing in detail a configuration of a frame rewrite unit 205 according to the first embodiment of the invention;

Fig. 21 is a block diagram showing in detail a configuration of a frame aggregate unit 206 according to the first embodiment of the invention;

Fig. 22 is a block diagram showing in detail a configuration of a frame transfer unit 207 according to the first embodiment of the invention;

Fig. 23 is a block diagram showing a configuration of processing realized by software in a CPU 30 according to the first embodiment of the invention;

Fig. 24 is a table showing a configuration of a TAG address management table 70134 according to the first embodiment of the invention;

Fig. 25 is a flow chart explaining in detail an operation of an event 01 according to the first embodiment of the invention;

Fig. 26 is a flow chart explaining in detail an operation of an event 11 according to the first embodiment of the invention;

Fig. 27 is a flow chart explaining in detail an operation of an event 03 according to the first embodiment of the invention;

5 Fig. 28 is a flow chart explaining in detail an operation of an event 12 according to the first embodiment of the invention;

Fig. 29 is a flow chart explaining in detail an operation of an event 05 according to the first embodiment of the invention;

10 Fig. 30 is a flow chart explaining in detail an operation of an event 13 according to the first embodiment of the invention;

Fig. 31 is a flow chart explaining in detail an operation of an event 06 according to the first embodiment of the invention;

15 Fig. 32 is a flow chart explaining in detail an operation of an event 14 according to the first embodiment of the invention;

Fig. 33 is a topology diagram showing a configuration example of a tree T0 according to the first embodiment of the invention;

Fig. 34 is a topology diagram showing a configuration example of a tree T1 according to the first embodiment of the invention;

25 Fig. 35 is a topology diagram showing a configuration example of a tree T2 according to the first embodiment of the invention;

Fig. 36 is a topology diagram showing a configuration example of a tree T3 according to the first embodiment of the invention;

5 Fig. 37 is a topology diagram showing a configuration example of a tree T4 according to the first embodiment of the invention;

Fig. 38 is a sequence chart of an operation example 1 according to the first embodiment of the invention;

10 Fig. 39 is a sequence chart of an operation example 2 according to the first embodiment of the invention; and

15 Fig. 40 is a sequence chart of an operation example 3 according to the first embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiment of the present invention will be discussed hereinafter in detail with reference to the accompanying drawings. In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be obvious, however, to those skilled in the art that the present invention may be practiced without these specific details. In other instance, well-known structures are not shown in detail in order to unnecessary obscure the present invention.

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The preferred embodiment of the present invention will be described in detail with reference to the accompanying drawings.

Fig. 1 is a block diagram showing a configuration example of a physical network to which the present invention is applied.

The physical network of Fig. 1 is configured of nodes G1 to G4 which are connected to form a ring shape, the node G1 is an Ethernet switch having a downlink port (D/L) and uplink ports (U/L), a client is connected to the downlink port, and a switch is connected to the uplink ports. In this embodiment, a client C1 is connected to the downlink port (D/L), and the node G3 and the node G4 are connected to the uplink ports (U/L) respectively.

The node G1 performs the following operation on the physical network of Fig. 1.

(1) A frame arrived from the client C1 is added a tag for forwarding or the like if necessary and transferred to one or both of the nodes G3 and the node G4.

(2) A frame arrived from the node G3 is removed an added tag if necessary and transferred to one or both of the client C1 and the node G4.

(3) A frame arrived from the node G4 is removed an added tag if necessary and transferred to one or both of the client C1 and the node G3.

(4) A learning frame is sent and received between the node G1 and the node G3 or the node G4 to exchange address information required for the frame transfer shown in (1) to (3).

5 (5) A BPDU frame specified by a high-speed spanning tree protocol is sent and received between the node G1 and the node G3 or the node G4 to exchange path information required for execution of the operations (1) to (4).

10 The node G2 is a node having the same configuration and function as the node G1 and an Ethernet switch having the downlink port (D/L) and the uplink ports (U/L). The client is connected to the downlink port, and the switch is connected to the uplink
15 ports. According to the embodiment, the client C2 is connected to the downlink port (D/L), and the node G3 and the node G4 are connected to the uplink ports (U/L).

The node G2 operates as follows on the physical network shown in Fig. 1.

20 (1) A frame arrived from the client C2 is added a tag for forwarding or the like if necessary and transferred to one of both of the node G3 and the node G4.

 (2) A frame arrived from the node G3 is removed
25 the added tag if necessary and transferred to one or both of the client C2 and the node G4.

 (3) A frame arrived from the node G4 is removed

the added tag if necessary and transferred to one or both of the client C2 and the node G3.

5 (4) A learning frame is sent and received between the node G2 and the node G3 or the node G4 to exchange address information required for the frame transfer shown in (1) to (3).

10 (5) The BPD frame specified by a high-speed spanning tree protocol is sent and received between the node G2 and the node G3 or the node G4 to exchange path information required for execution of the operations shown in (1) to (4).

15 The node G3 is a node having the same configuration and function as the node G1 and an Ethernet switch having the downlink port (D/L) and the uplink ports (U/L). The client is connected to the downlink port, and the switch is connected to the uplink ports. According to this embodiment, the client C3 is connected to the downlink port (D/L), and the node G1 and the node G2 are connected to the uplink ports (U/L).

20 The node G3 operates on the physical network of Fig. 1 as follows.

(1) A frame arrived from the client C3 is added a tag for forwarding or the like if necessary and transferred to one or both of the node G1 and the node G2.

25 (2) A frame arrived from the node G1 is removed the added tag if necessary and transferred to one or

both of the client C3 and the node G2.

(3) A frame arrived from the node G2 is removed the added tag if necessary and transferred to one or both of the client C3 and the node G1.

5 (4) The learning frame is sent and received between the node G3 and the node G1 or the node G2 to exchange address information required for execution of the frame transfer shown in (1) to (3).

10 (5) The BPDU frame specified by the high-speed spanning tree protocol is sent and received between the node G3 and the node G1 or the node G2 to exchange path information required for execution of the operations shown in (1) to (4).

15 The node G4 is a node having the same configuration and function as the node G1 and an Ethernet switch having the downlink port (D/L) and the uplink ports (U/L). The client is connected to the downlink port, and the switch is connected to the uplink ports. According to this embodiment, nothing is
20 connected to the downlink port (D/L), and the node G1 and the node G3 are connected to the uplink ports (U/L).

 The node G4 operates as follows on the physical network shown in Fig. 1.

25 (1) A frame arrived from the node G1 is transferred to the node G2 if necessary.

 (2) A frame arrived from the node G2 is transferred to the node G1 if necessary.

(3) The learning frame is sent and received between the node G4 and the node G1 or the node G2 to exchange address information required for execution of the frame transfer operation shown in (1) to (2).

5 (4) The BPDU frame specified by the high-speed spanning tree protocol is sent and received between the node G4 and the node G1 or the node G2 to exchange path information required for execution of the operations shown in (1) to (3).

10 The client C1 means a personal computer, a server, a router, a switch and all other electronic equipment for sending and receiving Ethernet frames. According to this embodiment, the client C1 will be described assuming a combination of a personal computer and basic
15 software capable of exchanging ICMP PING. The operation to be described here can also be executed in the same way for application other than the ICMP PING. This application includes sharing of files and a printer by NetBIOS or Apple Talk, TCP/IP, UDP/IP and HTTP, TELNET,
20 FTP, SMTP, POP, SSL and the like which are application using them. In this configuration example, the client C1 is connected to the downlink port (D/L) of the node G1

 The client C2 is a client similar to the client C1 and means a personal computer, a server, a router, a
25 switch and all other electronic equipment for sending and receiving other Ethernet frames. According to this embodiment, the client C2 will be described assuming a

combination of a personal computer and basic software capable of exchanging ICMP PING. In this configuration example, the client C2 is connected to the downlink port (D/L) of the node G2.

5 The client C3 is a client similar to the client C1 and means a personal computer, a server, a router, a switch and all other electronic equipment for sending and receiving other Ethernet frames. According to this embodiment, the client C3 will be described assuming a
10 combination of a personal computer and basic software capable of exchanging ICMP PING. In this configuration example, the client C3 is connected to the downlink port (D/L) of the node G3.

15 Fig. 2 is a block diagram showing a configuration of the Ethernet frame transferred over the network of Fig. 1.

 IEEE 802.3 Ethernet frame 60 is a frame format used for Ethernet and formed by the frame format of Fig. 2. For the network control frame, a special MAC address
20 is stored in the destination MAC address according to the standard.

 Fig. 3 is a block diagram showing a configuration of a VLAN Tagged Ethernet frame flowing on the network of Fig. 1.

25 IEEE802.3 VLANT Tagged Ethernet frame 61 is a frame with VLAN tag 606 of the IEEE802.3 Ethernet frame 60. It has a frame format used for the Ethernet and

formed in the frame format of Fig. 3. For the network control frame, a special MAC address is stored in the destination MAC address according to the standard, and the VLAN tag 606 for storing special network separation information is possessed within the frame.

Fig. 4 is a block diagram showing a configuration of the VLAN tag for the VLAN Tagged Ethernet frame of Fig. 3.

A frame format of the VLAN tag 606 is shown in Fig. 4. An identification ID of a tag indicating that the frame is tagged is stored in tag type 6061, and 0x8100 is stored in view of the standard. Priority information of 8-stage frame is stored using three bits for 0d000-0d111 in priority 6062. CFI6063 indicates that routing information for source routing to be used by a token ring is included. ID information for separating the network is stored in VLAN ID 6064. A node for relaying the frame refers to this ID to limit a route for transfer of the frame in the ID unit so to separate the network.

Fig. 5 is a block diagram showing a configuration of the Ethernet frame with the forwarding tag to be transferred over the network of Fig. 1.

Ethernet frame 62 with a forwarding tag is a frame with a tag 620 of the IEEE802.3 Ethernet frame 60. It has the same frame format as that used for the Ethernet and formed to have the frame format shown in

Fig. 5. For the network control frame, a special MAC address is stored in the destination MAC address according to the standard, and the destination MAC address has the tag 620 for storing information on relaying of the frame. A bit indicating the forwarding tag is used for priority/tag identification information 6201 of the tag 620.

Fig. 6 is a block diagram showing a configuration of the tag 620 for the Ethernet frame with the forwarding tag of Fig. 5.

A frame format of the tag 620 is shown in Fig. 6. The identification ID of a tag indicating that the frame has a tag is stored in tag type 6061, and the same 0x8100 as the standard is stored. For the priority/tag identification information 6201, 3 bits are used for 0d000-0d111, and priority information on a 4-stage frame and information indicating a tag type are stored. The tag type can be defined to have information to be stored in a tag according to a user's use, such as a forwarding tag indicating a frame's destination node or a source tag indicating a broadcast transfer source. CFI6063 indicates that routing information for source routing to be used for the token ring is included. Information corresponding to a tag type is stored in VLAN ID6202.

Fig. 7 is a block diagram showing a configuration of the learning frame flowing over the network of Fig. 1.

Learning frame 63 is a frame having the IEEE802.3

Ethernet frame 60 with the tag 620 and has a feature that the MAC address 631 for learning frame identification indicating that the frame is a learning frame stored in the destination MAC address. A bit
5 indicating a broadcast tag is used for the priority/tag identification information 6201 of the tag 620. And, it is the same frame format as that used for the Ethernet and formed to have the same frame format as in Fig. 5.

Fig. 8 is a block diagram showing a configuration
10 of a learning frame with the VLAN tag flowing over the network of Fig. 1.

The learning frame 63 is a frame which has the IEEE802.3 Ethernet frame 60 with the tag 620 added and has a feature that the MAC address 631 for learning
15 frame identification indicating that the frame is a learning frame is stored in the destination MAC address. For the priority/tag identification 6201 of the tag 620, a bit indicating a broadcast tag is used. And it has the same frame format as that used for the Ethernet and
20 formed in a format having a VLAN tag inserted into the frame format of Fig. 5.

Fig. 9 is a block diagram showing in detail a configuration of the node G1 (switching hub 1) shown in Fig. 1.

25 In Fig. 9, the switching hub 1 (namely, the node G1) is an Ethernet switch which is comprised of a packet forwarding unit 20, a CPU 30, a main memory 40 and a

console I/O 51 to which the method and circuitry of the present invention are applied. The switching hub 1 uses PHY 15, PHY 16, PHY 17, PHY 18, MAC 11, MAC 12, MAC 13 and MAC 14 to be connected to I/F (1), I/F (2), I/F (3) and I/F (4) so to send and receive the Ethernet frame.

The packet forwarding unit 20 applying the present invention transfers the received frame to an appropriate interface, has a transfer control program stored in the CPU 30 and the main memory 40 and gives a control instruction to the packet forwarding unit.

Fig. 10 is a block diagram showing in detail a configuration of the packet forwarding unit 20 shown in Fig. 9.

The packet forwarding unit 20 is comprised of frame analyzer 201, learning frame transmission management unit 202, forwarding table 204 and table search unit 203 including the functions of the invention in addition to frame rewrite unit 205, frame aggregate unit 206 and frame transfer unit 207 of a conventional circuit.

The packet forwarding unit 20 has a mechanism to receive the IEEE802.3 Ethernet frame 60 of Fig. 2, the IEEE802.3 VLAN Tagged Ethernet frame 61 of Fig. 3, the Ethernet frame with a forwarding tag of Fig. 5 and the learning frame 63 of Fig. 6 as input frame 101 and to transfer as output frame 102 to the MAC 11, the MAC 12, the MAC 13 and the MAC 14 to be connected to the I/F (1),

th I/F (2), the I/F (3) and th I/F (4).

In the CPU 30, network control program 304 and equipment control program 305 which are programs for network control and equipment control are executed, and forwarding table control program 301, which performs frame sending processing and manipulates information in the forwarding table memory of Fig. 16, Fig. 17 and Fig. 18 to be described later, is being executed. The forwarding table control program 301 outputs information required for network control to table write information 3012 and table write address 3011 to forwarding table 204 according to instructions of learning management program 302 or spanning tree control program 303 which similarly runs on the CPU 30 so to control the transmission and reception of information required for the network control.

The main memory 40 stores the individual programs executed on the CPU 30 shown in Fig. 23 and memory duplicate information 3013 shown in Fig. 23.

The memory duplicate information 3013 has four tables, namely tag forwarding table memory 70131, broadcast table memory 70132, MAC forwarding table memory 70133 and TAG address management table 70134.

The tag forwarding table memory 70131 has a table, which has the same contents as the tag forwarding table memory 2041 shown in Fig. 15, created on the main memory 40.

The broadcast table memory 70132 has a table, which has the same contents as the broadcast table memory 2041 shown in Fig. 15, created on the main memory 40.

5 The MAC forwarding table memory 70133 has a table, which has the same contents as the MAC forwarding table memory 2043 shown in Fig. 15, created on the main memory 40.

10 Fig. 11 is a block diagram showing in detail a configuration of the frame analyzer 201 shown in Fig. 10.

 The frame analyzer 201 of Fig. 11 has functions to analyze the frame of input frame 101 and to send table search key information 20131 for determining a transfer path, frame header information 20141 and a control frame to the CPU 30.

15 Frame type judgment unit 2011 judges a frame type of the input frame 101 and an input port type. Specifically, it is judged which of the IEEE802.3 Ethernet frame 60, the IEEE802.3 VLAN Tagged Ethernet frame 61, the Ethernet frame with a forwarding tag and the learning frame 63 is the frame type. The input port type is judged according to an input port number on the basis of an attribute of the port determined from equipment control program 305 of Fig. 23 and information on whether the input port is an uplink port or a downlink port. The judged information is sent to search key decision unit 2013 and frame header analyzer 2014.

And, the input frame 101 is sent to the control frame receive unit 2012 and the frame header analyzer 2014.

5 The frame header analyzer 2014 extracts frame header information and judges a destination MAC address and a tag type from information on the input frame 101 and the judged information sent from frame type judgment unit 111.

10 The destination MAC address is judged whether it is an ordinary MAC address, a MAC address for the network control frame or a MAC address for learning frame identification. The tag type is judged whether it is VLAN tag 606, a forwarding tag (own node destination, another node destination) or a broadcast tag. Such judgment information is sent to the search key decision unit 2013. And, frame's input port information, destination MAC address 601, source MAC address 602, VLAN tag 606, tag 620 and Ethernet attribute information 603 extracted from the frame are output as the frame header information 20141, and payload 604 is output as
15 input frame payload information 20111.
20

 The search key decision unit 2013 determines a key to be used for table search from information on frame types, input port types, destination MAC address types and tag types sent from the frame type judgment unit 2011 and the frame header analyzer 2014.
25

 The determined key information is output as the table search key information 20131. The search key

determination method determines a transfer key addressed to the CPU when the MAC destination address is for the network control frame or for the learning frame identification and notifies control frame receive unit 2012 of the CPU destination transfer frame.

For the Ethernet frame 62 with a forwarding tag addressed to another node, key information for searching a tag forwarding table and a broadcast forwarding table is output, and for the Ethernet frame 62 with a forwarding tag addressed to own node, the IEEE802.3 Ethernet frame 60 and the IEEE802.3 VLAN Tagged Ethernet frame 61, key information for searching a MAC forwarding table and a broadcast forwarding table is output.

When a CPU destination transfer frame is instructed from the search key decision unit, the control frame receive unit 2012 outputs the input frame 101 input from the frame type judgment unit 2011 as CPU destination transfer frame 20121.

Fig. 12 is a block diagram showing in detail a configuration of the learning frame transmission management unit 202 shown in Fig. 10.

The learning frame transmission management unit 202 of Fig. 12 is provided with MAC SA table cache 2025 which manages a learning frame sending request to make the same frame not to frequently make a learning operation request to the CPU 30 so as to realize a function of lowering a processing load of the CPU. And,

this learning frame transmission management unit 202 operates to check a frame requiring a learning operation and to request the CPU to send the learning frame.

5 Learning frame management unit 2021 receives the frame header information 20141 from the frame analyzer 201 to check a source MAC address and makes a learning frame sending request. An operation therefor becomes as follows.

10 After the MAC source address of the frame header information is checked, the MAC SA table cache 2025 is read to check whether the same MAC source address is entered or not. Then, if there is no entry, learning frame transmission request 20231 is output together with the frame header information 20141 to transmission
15 request unit 2023. At the same time, the MAC source address information is entered the MAC SA table cache 2025. If the same MAC destination address has been entered at the time of checking, no transmission request is output.

20 There is also provided a function of clearing to zero the MAC SA table cache 2025 according to a request from aging request acceptance unit 2022.

25 Fig. 13 is a block diagram showing in detail a configuration of the MAC SA table cache 2025 shown in Fig. 12.

 The MAC SA table cache 2025 has a function to store a MAC source address of the frame and holds MAC

source address information of the received frame as shown in Fig. 13. When a new frame is received, the MAC source address of its frame is stored as MAC SA information in this MAC SA table cache 2025. If there is
5 the same information at the time of the second reception, the MAC source address is not stored in the entry.

The transmission request unit 2023 requests the CPU 30 to send a learning frame. When a learning frame sending request is made from the learning frame
10 management unit 2021, the learning frame transmission request 20231 is output to make the CPU 30 execute the learning frame sending processing.

The aging request acceptance unit 2022 receives learning aging request 3021 from the CPU 30. Upon
15 receiving the learning aging request 3021, the aging request acceptance unit 2022 requests the learning frame management unit 2021 to clear all entries of the MAC SA table cache 2025.

Fig. 14 is a block diagram showing in detail a
20 configuration of the table search unit 203 shown in Fig. 10.

The table search unit 203 of Fig. 14 has a function to determine a transfer destination of the frame and is comprised of table management unit 2031 and
25 information comparison unit 2032.

The table management unit 2031 performs a table search of forwarding table 204 to search a transfer

destination according to the table search key
information 20131.

5 The frame header information 20141 is output from
the table search unit 203 to the frame rewrite unit 205
for rewriting the frame header.

10 The table search unit 203 inputs search
instructions from the table search key information 20131
to the tag forwarding table memory 2041, MAC forwarding
table memory 2043 and broadcast forwarding table memory
2042. When information on plural search keys is input,
search instructions to individual tables are output as
table read address 20311 to the forwarding table 204 in
order of tag forwarding table>MAC forwarding
table>broadcast forwarding table.

15 As a result of searching the individual tables,
when the retrieval header information agrees with the
table entry information, hit information is received
from the information comparison unit 2032, and when it
does not agree, mishit information is received. The same
20 table is searched for different addresses until there is
a hit, or search instructions to the next order of
priority are given to the forwarding table 204. When
there is a hit while referring to the MAC forwarding
table, entry hit information 20312 is output and stored
25 in the entry of MAC-Tag entry management information
when an entry type is MAC→Tag or in the entry of MAC-
Port entry management information when the entry type is

MAC→Port having the hit reference address as a memory address with respect to the aging management table 2044 of Fig. 19 through table memory read control circuit 2046.

5 And, header information which is subject to the table search is extracted from the frame header information 20141 and output to the information comparison unit 2032 so as to compare with the table information obtained from the forwarding table 204. The
10 header information to be output includes VLAN ID tag information 6202 when the tag forwarding table memory 2041 is searched, destination MAC address 601 and the VLAN tag 606 when the MAC forwarding table memory 2043 is searched and the VLAN ID tag information 6202 and the
15 VLAN ID 6064 when the broadcast forwarding table memory 2042 is searched. The information comparison unit 2032 is instructed to output tag remove as tag control information 20322 only for a forwarding tagged Ethernet frame addressed to the own node.

20 The information comparison unit 2032 compares the result of searching of the forwarding table 204 made by the table management unit 2031 with header information subject to the search to determine the output port. As described above, the information comparison unit 2032
25 receives input port information of the frame, the VLAN ID tag information 6202, the destination MAC address 601, the VLAN tag 606, header information of the VLAN ID 6064

from the table management unit 2031 according to each
table search, receives as table information 20451 a
result obtained when the table management unit 2031
gives table read-in instructions to the forwarding table
5 204, compares information according to each table type,
and outputs the entry information and output port
information 20321. To output the output port information
20321, it is compared with the input port information,
and if they are the same port information, the output
10 port information is not output in order to prevent the
frame from looping, and the frame is discarded. The
operation contents when each table is referred are
described below.

When the tag forwarding table memory 2041 is
15 referred, header information is not necessary to compare
because the VLAN ID tag information 6202 has become a
memory address to be referred. Output port information
and fault-time output port information of the tag
forwarding table memory 2041 of Fig. 17 are output to
20 output port information 20321. If there is no entry,
entry mishit information is output to the table
management unit 2031.

When referring to the MAC forwarding table memory
2043, retrieval header information is compared with MAC
25 destination address and destination's first stage TAG
information on the table entry of the MAC forwarding
table memory 2043 of Fig. 16, and if they agree, output

port information and fault output port information described in the table entry are output to output port information 20321, tag information is output as the tag information 20323, and tag control information is output
5 as the tag control information 20322. If they did not agree, entry mishit information is output to the table management unit 2031.

When referring to the broadcast forwarding table memory 2042, the header information is a memory address
10 which is referred to by the VLAN ID tag information 6202 or the VLAN ID 6064, so that it is not necessary to compare the information. It is checked whether port numbers not registered as plural output port information do not agree with input port information, and if they
15 agree, the frame is discarded, and if they do not agree, plural output port information of the broadcast forwarding table memory 2042 of Fig. 18 are output as the output port information 20321. If there is no entry at the reference memory address destination, entry
20 mishit information is output to the table management unit 2031.

Fig. 15 is a block diagram showing in detail a configuration of the forwarding table 204 shown in Fig. 10.

25 Information for transferring the frame is stored as table information in the forwarding table 204 of Fig. 15.

The table memory read control circuit 2046 reads a table address to be read from the table search unit 203 and outputs the result. The reading process of each table is made as follows.

5 (1) At the time of reading into the tag forwarding table memory 2041 of Fig. 17, the VLAN ID tag information 6202 is received as a table read address, the same memory address as that information is referred, and output port information and fault-time output port
10 information which are entered there are output to memory information output circuit 2045.

 (2) At the time of reading into the MAC forwarding table memory 2043 of Fig. 16, after the table read address is received, its address is determined as a
15 memory address, the aging management table 2044 shown in Fig. 19 is referred, and MAC-Tag entry management information and MAC-Port entry management information are referred. Then, if two entries are not invalid, the same memory address is used to access the MAC forwarding
20 table memory 2043, the table information is read, and the table entry information is output to the memory information output circuit 2045. If both the two entries are invalid, the MAC forwarding table memory 2043 is not referred, and the absence of entry is output as the
25 entry hit information 20312.

 (3) At the time of reading into the broadcast forwarding table memory 2042 of Fig. 18, the VLAN ID tag

information 6202 or the VLAN ID 6064 is received as an
table read address, the same memory address as that
information is referred, the output port information and
the fault-time output port information which are entered
5 there are output to the memory information output
circuit 2045.

The memory information output circuit 2045
outputs as the table information 20451 the table entry
information which was read by the table memory read
10 control circuit 2046 to the table search unit 203.

Fig. 16 is a block diagram showing in detail a
configuration of the MAC forwarding table memory 2043
shown in Fig. 15.

The MAC forwarding table memory 2043 has the
15 individual entries stored by the table configuration of
Fig. 16 and is used to store transfer destination
information of IEEE802.3 Ethernet frame and IEEE803.3
VLAN Tagged Ethernet frame. The memory address range is
arbitrary and has the same memory address range as the
20 aging management table 2044. According to this block
configuration, an example of the memory address range is
0x00000 to 0x7FFFF and can store a maximum of 8388706.
For the MAC destination address, the frame destination
MAC address 601 is stored, and for the destination first
25 stage TAG information, information corresponding to the
VLAN tag 606 of the frame is stored. As entry types, two
entry types, MAC→Tag indicating the entry having the

occurrence of the tag 620 imparting process and MAC→Port not involving the occurrence of a tag processing are managed. For output port information, a port number of a transfer destination is stored, for a fault-time output
5 port number, an output port number at the time of occurrence of a fault is stored, for TAG control information, the presence or not of tag insertion operation to the frame is stored, and for TAG
10 information, tag information to be inserted at the time of tag insertion is stored.

Fig. 17 is a block diagram showing in detail a configuration of the tag forwarding table memory 2041 shown in Fig. 15.

The tag forwarding table memory 2041 stores the
15 individual entries by the table structure of Fig. 17 and is used to store transfer destination information of forwarding-tagged frames. The memory address range is 0x0000 to 0x1000, and a maximum of 4096 entries are stored. For output port information, frame's transfer
20 destination port numbers are stored, and for fault-time output port information, port information to be transferred when the output port has a failure is stored.

Fig. 18 is a block diagram showing in detail a configuration of the broadcast table memory 2042 shown
25 in Fig. 15.

The broadcast forwarding table memory 2042 has the table configuration of Fig. 18 to store individual

entries and is used to store broadcast transfer destination information of the broadcast-tagged Ethernet frame, IEEE802.3 Ethernet frame and IEEE803.3 VLAN Tagged Ethernet frame. The memory address range is 0x0000 to 0x1000, and a maximum of 4096 entries are stored. For plural output port information, plural port numbers which may perform broadcast transfer are stored.

Fig. 19 is a block diagram showing in detail a configuration of the aging management table 2044 shown in Fig. 15.

The aging management table 2044 has the configuration of Fig. 19 to store the individual entries and is used to manage the entry access states of the MAC forwarding table memory 2043 and the presence or not of the entries. The memory address range is arbitrary and has the same memory address range as MAC forwarding table memory 2043. In the MAC-TAG entry management information, a state of access of the entry that an entry type of MAC forwarding table memory is MAC→Tag and information on the presence or not of entry are stored, and no hit indicates an unused entry, the hit indicates an entry used for transfer, the entry invalid indicates that the entry is invalid, and the entry protected indicates that the entry cannot be removed. Similarly, in the MAC-Port entry management information, a state of access of the entry that an entry type of MAC forwarding table memory is MAC→Port and information on the presence

or not of entry are stored.

Aging control unit 2047 performs an aging operation for the entry of the aging management table 2044. The aging operates as follows. Information on application of aging to which an entry type of MAC→Port or MAC-Tag and also an aging request are received as MAC/TAG aging control 3022 from the CPU 30. Upon receiving the request, the aging control unit 2047 accesses the aging management table 2044, reads all information on subject entry types, changes the contents of entry to the no hit when information is stored as a hit, changes the contents of entry to the entry invalid when information is stored as no hit and notifies its memory address to the CPU 30.

Table memory write control circuit 2048 operates to write the entry into each table. When a memory address of any of the MAC forwarding table memory 2043, tag forwarding table 2041 and the broadcast table memory 2042 is input from table write address 3011, and the table write information 3012 is written as table entry into the memory address.

Fig. 20 is a block diagram showing in detail a configuration of the frame rewrite unit 205 shown in Fig. 10.

The frame rewrite unit 205 of Fig. 20 operates to rewrite the header contents of the frame.

Frame header buffer 2054 is used as a buffer for

storage and rewrite of the header information of the frame. Information of the frame header information 20141 is input to the frame header buffer 2054, tag insertion to or remove from the frame header is made by tag
5 insertion unit 2052 or tag remove unit 2053, then the rewritten frame header is output as frame header information 20541. If there is no operation by the tag insertion unit 2052 or the tag remove unit 2053, frame header information 141 is output as it is as the frame
10 header information 20541.

Tag control unit 2051 controls the insertion and remove of the tag with respect to the header of the frame. For a frame which needs header rewrite processing, tag operation information is received as the tag control
15 information 20322, and tag information necessary for processing of the tag is received as the tag information 20323 from the table search unit 203. When the tag control information 20322 is tag insertion instructions, the tag information 20323 is output to the tag insertion
20 unit 2052 to insert the tag information 20323 to the frame header. When it is tag remove instructions, the tag remove instructions are output to the tag remove unit 2053 to remove the tag information of the frame header.

25 The tag insertion unit 2052 inserts the tag to the header of the frame. After receiving the tag information 20323 from the tag control unit 2051, the

tag insertion unit 2052 operates to insert the tag to the frame header information 20141 which is stored in the frame header buffer 2054.

5 The tag remove unit 2053 removes the tag from the header of the frame. After receiving tag remove instructions from the tag control unit 2051, the tag remove unit 2053 operates to remove the tag from the frame header information 20141 stored in the frame header buffer 2054.

10 Fig. 21 is a block diagram showing in detail a configuration of the frame aggregate unit 206 shown in Fig. 10.

15 The frame aggregate unit 206 of Fig. 21 combines the rewritten frame header and frame payload information to reconfigure an outputable frame.

20 The rewritten frame header information is stored in input frame header information control buffer 2062. When the frame header information 20541 is received, a frame header information acceptable state is notified to frame assembly unit 2064.

25 Frame payload information is stored in input frame payload information control buffer 2063. After the input frame payload information 20111 is received, a frame payload information acceptable state is notified to the frame assembly unit 2064.

 The frame assembly unit 2064 assembles the frame header information and the payload information. After

receiving the information acceptance notice from the
input frame header information control buffer 2062 and
the input frame payload information control buffer 2063,
the header information and the payload information are
5 read from the buffer, and the frame header and the
payload information are combined and output as output
frame information 20641.

Fig. 22 is a block diagram showing in detail a
configuration of the frame transfer unit 207 shown in
10 Fig. 10.

The frame transfer unit 207 of Fig. 22 transfers
the frame according to the output port information.

Frame transfer management unit 2072 transfers the
frame to the designated output port. When the output
15 port information 20321 is received from the table search
unit 203, the frame stored in output frame buffer 2073
is output as output frame 102 to the port of its output
port number. At this time, if the output port number
indicates addressing to the CPU, the frame is output as
20 the CPU destination transfer 20121.

And, after receiving CPU transfer frame
information 3041 and CPU transfer frame output port
information 3042, which are used if there is a frame
transmission request from the CPU, from CPU transfer
25 frame control unit 2071, the CPU transfer frame
information 3041 is output as the output frame 102 to
the designated port number.

The output frame information 20641 assembled by the frame aggregate unit 206 is stored in the output frame buffer 2073, and the frame in the buffer is output as the output frame 102 by the frame transfer management unit 2072.

The CPU transfer frame control unit 2071 receives from the CPU 30 frame information desired to be transferred as the CPU transfer frame information 3041 and output port information to be transferred as the CPU transfer frame output port information 3042 and gives frame transfer instructions to the frame transfer management unit 2072.

Fig. 23 is a block diagram showing a configuration of processing to be realized by software in the CPU 30 shown in Fig. 10.

The network control program 304 performs the following three operations.

(1) It receives a CPU destination transfer frame which is sent by the control frame receive unit 2012 and transfers the frame to the equipment control program 305, the learning management program 302 or the spanning tree control program 303 according to a designation MAC address of the received frame.

(2) Simultaneously with (1), the CPU transfer frame output port information 3042 and the CPU transfer frame information 3041 are used if necessary to retransfer the frame received in (1).

(3) The frame whose transmission was requested by the equipment control program 305, the learning management program 302 or the spanning tree control program 303 is written to the CPU transfer frame output port information 3042 and the CPU transfer frame information 3041.

When the frame received as the CPU destination transfer frame 20121 by the network control program 304 has a destination MAC address of 00-00-4C-00-00-00, the frame is transferred to the learning management program 302 and, at the same time, the CPU transfer frame output port information 3042 and the CPU transfer frame information 3041 are used to transfer the frame for broadcast.

When the frame received as the CPU destination transfer frame 20121 by the network control program 304 has a destination MAC address of 01-80-C2-00-00-00, the frame is transferred to the spanning tree control program 303.

When the frame received as the CPU destination transfer frame 20121 by the network control program 304 has a destination MAC address other than the above addresses, the frame is transferred to the equipment control program 305.

The spanning tree control program 303 performs the following three operations.

(1) According to a high-speed spanning tree

protocol (IEEE802.1W) or a spanning tree protocol (IEEE802.1D), a BPDU frame is exchanged through the adjacent node and the network control program 304 to construct a spanning tree. Setting required for the tree construction is made by the equipment control program 305.

(2) The tag forwarding table memory 2041, the broadcast forwarding table 2042 and the memory duplicate information 3013 which is a duplicate on the side of software of the above two memories are set from the port information (alternate port, root port, designated port, etc.) of the spanning tree constructed in (1) through the forwarding table control program 301.

(3) If a route port change is detected by the BPDU exchange, a route port change (event 14) is notified to the learning management program 302.

The equipment control program 305 accepts the setting through the console I/O 51 or a setting interface using TELNET, SSH and HTTP provided via the network control program 304 and notifies the frame type judgment unit 2011 of the setting information through the learning management program 302, the spanning tree control program 303 and port configuration information 3051.

The forwarding table control program 301 performs the following operation.

(1) According to the instructions from the

spanning tree control program 303, the table write
information 3012 and the table write address 3011 are
used to make entry write or entry substitution of the
tag forwarding table memory 2041 and the broadcast
5 forwarding table memory 2042.

(2) Simultaneously with (1), the memory duplicate
information 3013 is used to perform entry write or entry
substitution of the software table.

(3) According to the instructions from the
10 learning management program 302, the table write
information 3012 and the table write address 3011 are
used to perform entry write or entry substitution of the
MAC forwarding table memory 2043.

(4) Simultaneously with (3), the memory duplicate
15 information 3013 is used to perform entry write or entry
substitution of the software table.

(5) According to the instructions from the
learning management program 302, the memory duplicate
information 3013 is used to perform an entry search in
20 the software table.

(6) According to the instructions from the
network control program 304, the memory duplicate
information 3013 is used to perform an entry search in
the software table.

25 The learning management program 302 receives the
learning frame transmission request 20231, an aging
trigger from timer 306, a learning frame from the

network control program 304, and a spanning tree change notice from the spanning tree control program 303, activates the events shown below, and performs registration, substitution and remove of the MAC forwarding table memory 2043 and its duplicate information.

(1) When the learning frame transmission request 20231 reaches the learning management program 302, event 01 is activated.

(2) When the learning frame reaches the learning management program 302 from the network control program 304, event 03 is activated.

(3) When the port learning aging trigger reaches the learning management program 302 from the timer 306, event 12 is activated.

(4) When the tag learning aging trigger reaches the learning management program 302 from the timer 306, event 13 is activated.

(5) When a route node change notice reaches the learning management program 302 from the spanning tree control program 303, event 14 is activated.

(6) When an initialization request reaches from the equipment control program 305, event 00 is activated.

The timer 306 generates the port learning aging trigger or the tag learning aging trigger every time determined by the equipment control program 305 to notify the learning management program 302.

Fig. 24 is a table showing a configuration of the TAG address management table 70134 contained in the memory duplicate information 3013 shown in Fig. 23.

5 The TAG address management table 70134 is comprised of two cells for destination first-stage TAG information and table storage address.

10 The destination first-stage TAG information includes TAG which becomes a search key of the TAG address management table 70134. All VLAN IDs contained in the TAG are determined to be even numbers. In case of registering an odd-number ID, one is deducted from the ID value to be registered for registration and search in an even-numbered address.

15 In the table storage address, there are indicated the addresses in the MAC forwarding table memory 70133 of the entries including TAG described in the destination first-stage TAG information. The number of addresses included in its cell is not particularly limited.

20 Fig. 25 is a flow chart illustrating in detail an operation of the event 01 by the learning management program 302 shown in Fig. 23.

25 The event 01 is activated when the learning frame transmission request 20231 reaches the learning management program 302. This event is software processing for adding the entry to the MAC forwarding table memory 70133 which is duplicate information on the

MAC forwarding table memory 2043 and the main memory 40 so that the destination port can be searched in view of the MAC DA and the tag.

5 In step N0101, processing of the event 01 is started. A result of judgment by a frame analyzer, the port to which the frame is input, the source MAC address and the tag information are notified from the learning management program. The process advances to step N0102.

10 In step N0102, the MAC forwarding table memory 70133 is searched through the forwarding table control program 301 to check whether information to be registered has been given in the table. If the search results in hit, the processing is terminated, but if mishit, the process advances to step N0103.

15 In step N0103, the judged result by the frame analyzer notified in the step N0101 is examined, and if the frame to be learnt has been input from the uplink side, the process moves to step N0105. If it is input from the downlink, the process moves to step N0104.

20 In the step N0104, event 11 is activated, the learning frame is broadcasted to another node. When the event is activated, the source MAC address and tag information notified in the step N0101 are notified. Then, the process moves to step N0105.

25 In the step N0105, an entry is added as the memory duplicate information 3013 to the MAC forwarding table memory 70133 on the main memory 40 through the

forwarding table control program 301. At this time, the source MAC address received in the step N0101 is set for the MAC destination address, the tag information received in the step N0101 is set for the destination first-stage TAG information, and the input port notified in the step N0101 is set for the output port information. Then, the process moves to step N0106.

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In the step N0106, an entry is added to the MAC forwarding table memory 2043 through the forwarding table control program 301. At this time, the source MAC address received in the step N0101 is set for MAC destination address, the tag information received in the step N0101 is set for destination first-stage TAG information, and the input port notified in the step N0101 is set for output port information. Thus, the process of the event 01 is terminated.

Fig. 26 is a flow chart illustrating in detail an operation of event 11 in the learning management program 302 shown in Fig. 23.

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The event 11 is activated to send the learning frame in the event 01 or event 05. This event is part of software processing for adding an entry to the MAC forwarding table memory 2043 and the MAC forwarding table memory 70133 which is duplicate information on the main memory 40 so that a tag to be added can be retrieved in view of the MAC DA and tag.

In step N1101, processing of event 11 is started.

At the start, source MAC address and tag are notified.
The process moves to step N1102.

5 In the step N1102, the broadcast forwarding table
memory 2042 on the main memory 40 is searched as the
memory duplicate information 3013 through the forwarding
table control program 301 to search an output
destination port of the learning frame. If the search
results in mishit, the processing is terminated, and the
process returns to the event procedure of event 11
10 activation source. If there is a hit, the process moves
to step N1103.

In the step N1103, the network control program
304, the CPU transfer frame output port information 3042
and the CPU transfer frame information 3041 are used to
15 request the CPU transfer frame control unit 2071 for
transmission of a learning frame having a source tag
indicating an own node address and a VLAN tag given in
the step N1101 added to the port searched in the step
N1102. Thus, the processing of the event 11 is
20 terminated, and the process returns to the event
procedure of event 11.

Fig. 27 is a flow chart illustrating in detail an
operation of event 03 according to the learning
management program 302 shown in Fig. 23.

25 The event 03 is activated when the learning frame
reaches the learning management program 302 from the
network control program 304. This event is software

processing for adding an entry to the MAC forwarding
table memory 2043 and the MAC forwarding table memory
70133 which is duplicate information on the main memory
40 according to the MAC DA and the tag so that the tag
5 to be added can be searched.

In step N0301, processing of the event 03 is
started. On start-up, the frame analyzer's judged result,
input port, MAC address, tag 1 and tag 2 are notified.
The process moves to step N0302.

10 In the step N0302, the tag forwarding table
memory 70131, which is on the main memory 40 as the
memory duplicate information 3013, is searched through
the forwarding table control program 301 to search for
an output destination port corresponding to the tag 1.
15 If the search is a mishit, the processing is terminated.
If it is a hit, the process moves to step N0303.

In the step N0303, the MAC forwarding table
memory 2043, which is on the main memory 40 as the
memory duplicate information 3013, is searched through
20 the forwarding table control program 301 so as to search
for the MAC address notified in the step N0301, an
additional tag to and tag 2, an output port and a spare
output port. If the search is a mishit, the process
moves to step N0305. If it is a hit, the process moves
25 to step N0304.

In the step N0304, it is checked whether the
output port and spare output port searched in the step

N0302 and the output port and spare output port searched in the step N0303 are in perfect match and whether the tag 1 notified in the step N0301 and the additional tag searched in the step N0303 are in match. If there is a perfect match, the processing is terminated, but if not, the process moves to step N0305.

In the step N0305, an entry is added to the MAC forwarding table memory 70133, which is on the main memory 40 as the memory duplicate information 3013, through the forwarding table control program 301. At this time, the MAC address received in the step N0301 is added to the MAC destination address, the tag received in the step N0301 is added to the tag, the port retrieved in the step N0303 is added to the output destination port and spare output port, and the forwarding tag notified in the step N0301 is added to the tag to be added. The process moves to step N0306.

In the step N0306, an entry is added to the MAC forwarding table memory 2043 through the forwarding table control program 301. At this time, the MAC address received in the step N0301 is added to the MAC destination address, the tag received in the step N0301 is added to the tag, the port searched in the step N0303 is added to the output destination port and spare output port, the forwarding tag notified in the step N0301 is added to the tag to be added. The process moves to step N0307 or step N0308.

In the step N0307, the entry is removed from the TAG address management table 70134, which is on the main memory 40 as the memory duplicate information 3013, through the forwarding table control program 301. At
5 this time, the tag 1 received in the step N0301 is designated for an index tag, and the entry address obtained in the step N0303 is designated for a memory address. The process moves to step N0308.

In the step N0308, an entry is added to the TAG
10 address management table 70134, which is on the main memory 40 as the memory duplicate information 3013, through the forwarding table control program 301. At this time, the additional tag searched in the step N0303 is designated for the index tag, and the entry address
15 obtained in the step N0305 is designated for a memory address. But, the additional tag value shall always be an even number. Thus, the process of the event 03 is terminated.

Fig. 28 is a flow chart illustrating in detail an
20 operation of the event 12 by the learning management program 302 shown in Fig. 23.

The event 12 is activated when a timer event is generated by the timer 306. This event is part of software processing to perform aging processing of an
25 entry for search of a destination port in view of the MACDA and tag among the entries described in the MAC forwarding table memory 2043 and the MAC forwarding

table memory 70133 which is duplicate information on the main memory 40.

In step N1201, processing of event 12 is started. On start-up, offset address is notified. The process is
5 moved to step N1202.

In the step N1202, aging request of the MAC forwarding table memory 2043 and the MAC SA table cache 2025 on the side of hardware is made according to the learning aging request 3021 and the MAC/TAG aging
10 request 3022. The process moves to step N1203.

In the step N1203, the generation of event 12 is reserved into the timer 306 after a lapse of time designated through the equipment control program 305. At this time, a memory offset address is also registered.
15 Thus, processing of the event 12 is terminated.

Fig. 29 is a flow chart illustrating in detail an operation of event 05 in the learning management program 302 shown in Fig. 23.

The event 05 is activated when an aging
20 completion notice reaches from the MAC/TAG aging control 3022 after the aging request is made through the MAC/TAG aging control 3022 in the event 12. This event is part of software processing for aging processing of an entry to search a destination port from the MAC DA and tag
25 among the entries described in the MAC forwarding table memory 2043 and the MAC forwarding table memory 70133 which is duplicate information on the main memory 40.

In the step N0501, processing of the event 05 is started. On start-up, a result code, offset address and bit map are notified. The process moves to step N0502.

5 In the step N0502, entry address is generated in view of the offset and bit map notified in the step N0501. The process moves to step N0503.

10 In the step N0503, the entry of the entry address generated in the step N0502 is removed from the MAC forwarding table memory 70133, which is on the main memory 40 as the memory duplicate information 3013, through the forwarding table control program 301.

15 Processing in the step N0502 and step N0503 is performed on all addresses notified as the subjects to be removed in the step N0501. After the processing on all addresses is completed, the process moves to step N0504.

20 In the step N0504, event 11 is activated to send the learning frame to all entries, which are set to PTYPE=1 within the MAC forwarding table memory 70133. MAC DA and VLAN TAG are given as an argument to the event 11. After the processing on all entries is completed, the event 05 is also terminated.

25 Fig. 30 is a flow chart illustrating in detail an operation of the event 13 according to the learning management program 302 shown in Fig. 23.

The event 13 is activated when a timer event is caused by the timer 306. This event is part of the

software processing for aging processing of an entry to search a tag to be added in view of the MAC DA and tag among the entries described in the MAC forwarding table memory 2043 and the MAC forwarding table memory 70133 which is duplicate information on the main memory 40.

In step N1301, processing of the event 13 is started. On start-up, an offset address is notified. The process moves to step N1302.

In the step N1302, an aging request is made on the MAC forwarding table memory 2043 on the side of hardware by the MAC/TAG aging request 3022. The process moves to step N1303.

In the step N1303, the occurrence of event 13 is reserved to the timer 306 after a lapse of time designated through the equipment control program 305. At this time, a memory offset address is also registered. Then, the processing of the event 13 is terminated.

Fig. 31 is a flow chart illustrating in detail an operation of event 06 according to the learning management program 302 shown in Fig. 23.

After an aging request is made in the event 13 through the MAC/TAG aging control 3022, event 06 is activated when an aging completion notice arrives from the MAC/TAG aging control 3022. This event is part of software processing for aging processing of an entry to retrieve a tag to be added according to the MACDA and tag among the entries described in the MAC forwarding

table memory 2043 and the MAC forwarding table memory 70133 which is duplicate information on the main memory 40.

In step N0601, processing of event 06 is started.

5 On start-up, a result code, offset address and bit map are notified. The process moves to step N0602.

In the step N0602, an entry address is generated according to the offset and bit map notified in the step N0601. The process moves to step N0603.

10 In the step N0603, the entry of the entry address generated in the step N0602 is removed from the MAC forwarding table memory 70133, which is on the main memory 40 as the memory duplicate information 3013, through the forwarding table control program 301. The
15 process moves to step N0604.

In the step N0604, the entry of the entry address generated in the step N0603 is removed from the TAG address management table 70134, which is on the main memory 40 as the memory duplicate information 3013,
20 through the forwarding table control program 301.

The processing in the step N0602, step N0603 and step N0604 is performed on all addresses notified as the subjects to be removed in the step N0601. After all addresses are completed, the event 06 is terminated.

25 Fig. 32 is a flow chart illustrating in detail an operation of event 14 according to the learning management program 302 shown in Fig. 23.

The event 14 is activated when a change in spanning tree topology is detected by the spanning tree control program 303, and a route port, namely a frame output port, is changed. This event is software
5 processing for rewriting an output destination port and a spare output destination port described on the MAC forwarding table memory 2043 which has to be changed because of a change in tree topology and the MAC forwarding table memory 70133 which is duplicate
10 information on the main memory 40.

In step N1401, processing of the event 14 is started. On start-up, a tag subject to the topology change is notified. The process moves to step N1402.

In step N1402, the tag forwarding table memory
15 70131, which is on the main memory 40 as the memory duplicate information 3013, is searched through the forwarding table control program 301 to search an output destination port corresponding to a tag to be changed notified in the step N1401. If the search is a mishit,
20 the processing is terminated. If it is a hit, the process moves to step N1403.

In the step N1403, the TAG address management table 70134 is searched, and an entry address of the entry which has a tag to be changed notified in the step
25 N1401 determined as an additional tag on the MAC forwarding table memory 70133 is searched. If the search mishits, the processing is terminated, and if the search

is a hit, the process moves to step N1404.

In the step N1404, the entry of the MAC forwarding table memory 70133, which is on the main memory 40 as the memory duplicate information 3013, is substituted through the forwarding table control program 301. At this time, the port searched in the step N1402 is determined for the output destination port and spare output port, and other items are not substituted. The process moves to step N1405.

In the step N1405, the entry of the MAC forwarding table memory 2043, which is on the side of hardware, is substituted through the forwarding table control program 301. At this time, the port searched in the step N1402 is determined for the output destination port and spare output port, and other items are not substituted.

The operations of the step N1404 and step N1405 are performed on all address entries searched in the step N1403. After the substitution of all entries is completed, the event 14 is terminated.

Then, with reference to Fig. 33 to Fig. 37, a spanning tree topology configuration example having a logical network created by shutting off the port not to produce a loop in the physical network configuration example shown in Fig. 1 by using a high-speed spanning tree protocol specified in IEEE802.1W or a spanning tree protocol specified in IEEE802.1D will be described.

In each of Fig. 33 to Fig. 37, a thin line is used to indicate the link when either of two ports having a prescribed link is connected is prohibited from sending or receiving the frame, and a thick line is used to indicate the link only when both of two ports having a prescribed link connected can send and receive the frame.

In the description below, the frame may actually flow the link of a thin line for simplification of the description, but the description in this specification will be made on the assumption that no frame flows the link of a thin line. It is to be understood that such a way of description does not affect on the essential matter of the operation of the node according to the invention.

Fig. 33 is a topology diagram showing a configuration example of a tree T0 which is a logical network created when a high-speed spanning tree protocol or a spanning tree protocol is used on the physical network shown in Fig. 1.

In this configuration example, the tree T0 has node G1 as a root node and a port between node G3 and node G2 shut off, so to have the topology as shown in Fig. 33. This tree is created by exchanging a BPDU frame with no tag added according to the high-speed spanning tree protocol. The root node is determined to be any one of the node G1 to the node G4 according to the high-

speed spanning tree protocol. This logical network is used to transfer the frame not having a tag added.

Fig. 34 is a topology diagram showing a configuration example of tree T1 which is a logical network created when a high-speed spanning tree protocol or a spanning tree protocol is used on the physical network shown in Fig. 1.

In this configuration example, the tree T1 has the node G1 as the root node, and the port between the node G3 and the node G2 is shut off to form the topology shown in Fig. 34. This tree is created by exchanging a BPDU frame with tag g1 added according to the high-speed spanning tree protocol. In the tree T1, the root node is determined to be the node G1 by previously setting so that the node G1 is always a root node. This logical network is used to transfer the frame having the added tag g1 indicating that the node G1 is a destination.

Fig. 35 is a topology diagram showing a configuration example of tree T2 which is a logical network created when a high-speed spanning tree protocol or a spanning tree protocol is used on the logical network shown in Fig. 1.

In this configuration example, the tree T2 has the node G2 determined as the root node, and the port between the node G1 and the node G4 is shut off to form the topology shown in Fig. 35. This tree is created by exchanging the BPDU frame having the added tag g2

according to the high-speed spanning tree protocol. In the tree T2, the root node is determined to be the node G2 by previously setting so that the node G2 is always the root node. This logical network is used to transfer the frame having the added tag g2.

Fig. 36 is a topology diagram showing a configuration example of the tree T3 which is a logical network created when a high-speed spanning tree protocol or a spanning tree protocol is used on the logical network shown in Fig. 1.

In this configuration example, the tree T3 has the node G3 determined as the root node, and the port between the node G2 and the node G4 shut off to form the topology shown in Fig. 36. This tree is created by exchanging the BPDU frame having the added tag g3 according to the high-speed spanning tree protocol. In the tree T3, the root node is determined to be the node G3 by previously setting so that the node G3 is always the root node. This logical network is used to transfer the frame having the added tag g3.

Fig. 37 is a topology diagram showing a configuration example of the tree T4 which is a logical network created when a high-speed spanning tree protocol or a spanning tree protocol is used on the logical network shown in Fig. 1.

In this configuration example, the tree T4 has the node G4 determined as the root node, and the port

between the node G1 and the node G3 shut off to form the topology shown in Fig. 37. This tree is created by exchanging the BPDU frame having the added tag g4 according to the high-speed spanning tree protocol. In the tree T4, the root node is determined to be the node G4 by previously setting so that the node G4 is always the root node. This logical network is used to transfer the frame having the added tag g4.

Then, operation examples 1 to 3 of this embodiment will be described with reference to Fig. 38 to Fig. 40.

In the following sequence diagrams, a main signal frame sequence is indicated by a solid line, and a learning frame sequence is indicated by a broken line. A sequence of the frame having the added expansion tag is indicated by a thick line, and a sequence of the frame not having an added expansion tag is indicated by a thin line.

Fig. 38 is a sequence diagram showing an exchange of frames between the individual nodes and the client when client C1 sends PING REQUEST to client C2 and the client C2 sends back PING REPLY to the client C1. This is determined as operation example 1.

Sequence N111 is an operation immediately after the startup of a network operation or after a lapse of adequately long time after the termination of the previous communications between the client C1 and the

client C2, and is a communication sequence between the client C1 and the client C2 where MAC address c1 of the client C1 and address g1 of a node to which the client C1 belongs, MAC address c2 of the client C2 and address g2 of node to which client C2 belongs are not learned by the individual nodes of nodes G1 to G4. Here, an example shows that the client C1 sends ICMP ECHO REQUEST frame to the client C2, and the client C2 replies back ICMP ECHO REPLY frame.

First, the client C1 sends the client C2 the ICMP ECHO REQUEST frame having a destination MAC of c2 and a source MAC of c1. This frame will be referred to as the main signal frame in the following description.

The node G1 receives the frame from a downlink port. The destination MAC is used as a key to search a tag to be added and an output port, but the search does not make a hit because the learning of MAC address c2 has not completed. Therefore, the node G1 broadcasts the main signal frame along the tree T0. At this time, an operation of adding or removing the tag to or from the frame is not performed. As a result, the main signal frame is transferred to both the node G3 and the node G4.

Because the frame having an unlearned source MAC c1 added arrives from the downlink side, the node G1 learns that the MAC address c1 is connected to the port of the downlink side and broadcasts the learning frame having the source tag address g1 added to the uplink

side along the tree T1. As a result, the learning frame is transferred to both the node G3 and the node G4.

5 The node G3 receives from the uplink port the main signal frame which is sent from the node G1 to the destination MAC c2. At this time, it is learned that the frame addressed to the destination MAC address c1 may be sent to the uplink port to which the node G1 is connected. And, the output port is searched with the destination MAC c2 used as a key, but the search does
10 not result in a hit because the learning on the MAC address c2 has not completed. Therefore, the node G3 broadcasts the main signal frame to the tree T0 and the port on the downlink side. At this time, no operation is performed to add or remove a tag to or from the frame.
15 As a result, the main signal frame is transferred to the client c3 from the downlink port.

20 The node G3 receives the learning frame which is sent from the uplink side by the node G1 and learns that the client C1 having the MAC address c1 is connected to the downlink side of the node G1 having the expansion tag address g1. This learning upon arrival of the learning frame has precedence over the learning upon arrival of the main signal frame described above. Thus, when another frame addressed to the c1 is received from
25 the downlink side, the expansion forwarding tag g1 is added to the frame to transfer to the root port side of the tree T1. At the same time, the received learning

frame is broadcasted to the uplink side along the tree T1. But, the tree T1 is interrupted at the node G3, resulting in no further transfer of the learning frame from the node G3 to the next node.

5 The client C3 receives the main signal frame of the destination MAC c2 which is transferred by the node G3 but discards this frame because the destination MAC address does not match own MAC address c3.

10 The node G4 receives from the uplink port the main signal frame which is sent from the node G1 to the designation MAC c2. At this time, it is learned that the frame addressed to the destination MAC address c1 may be sent to the uplink port to which the node G1 is connected. And, the output port is searched with the
15 destination MAC c2 used as a key, but the search does not make a hit because the learning on the MAC address c2 has not completed. Therefore, the node G4 broadcasts the main signal frame to the tree T0 and the port on the downlink side. At this time, no operation to add or
20 remove a tag to or from the frame is performed. As a result, the main signal frame is transferred from the uplink port to the node G2 along the tree T0.

25 The node G4 receives the learning frame which is sent by the node G1 from the uplink side and learns that the client C1 having the MAC address c1 is connected to the downlink side of the node G1 having expansion tag address g1. This learning upon arrival of the learning

frame has precedence over the learning upon arrival of the main signal frame described above. Thus, when a frame addressed to the c1 is received from the downlink side from then on, the expansion forwarding tag g1 is added to the frame to transfer to the root port side of the tree T1. At the same time, the received learning frame is broadcasted to the uplink side along the tree T1. As a result, the learning frame is transferred to the node G2.

10 The node G2 receives from the uplink port the main signal frame addressed to the destination MAC c2 sent from the node G4. At this time, it is learned that the frame addressed to the destination MAC address c1 may be sent to the uplink port to which the node G4 is connected. And, the output port is searched with the destination MAC c2 used as a key, but the search does not make a hit because the learning on the MAC address c2 has not completed. Therefore, the node G2 broadcasts the main signal frame to the tree T0 and the port on the downlink side. At this time, no operation is performed to add or remove a tag to or from the frame. As a result, the main signal frame is transferred to the client C2 from the downlink port.

25 The node G2 receives from the uplink side the learning frame sent by the node G4 and learns that the client C1 having the MAC address c1 is connected to the downlink side of the node G1 having the expansion tag

address g1. This learning upon arrival of the learning frame has precedence over the learning upon arrival of the main signal frame described above. Thus, when a frame addressed to the c1 is received from the downlink side from then on, the expansion forwarding tag g1 is added to the frame to transfer to the root port side of the tree T1. At the same time, the received learning frame is broadcasted to the uplink side along the tree T1. But, because the tree T1 is interrupted at the node G2, the learning frame is not transferred from the node G2 to the next node.

The client C2 receives the main signal frame of the destination MAC address c2 transferred by the node G2. Because the destination MAC address matches own MAC address c2, this frame is given to an application or another program.

In this example, the frame sent from the client C1 is determined to be the ICMP ECHO REQUEST, so that the basic software of the client C2 creates an ICMP ECHO REPLY frame having the destination MAC address c1 and the source MAC address c2 to send to the node G2. This frame is referred to as the main signal frame in the following description.

The node G2 receives the frame from the downlink port. When a tag to be added and an output port are searched with the destination MAC used as a key, it is seen by the previous learning operation that the

expansion forwarding tag g1 may be added to the frame of the destination MAC address c1 to transfer to the root port side of the tree T1. Therefore, the node G2 adds the expansion forwarding tag g1 to the frame and
5 transfers to the node G4.

At the same time, the node G2 learns that the MAC address c2 is connected to the port on the downlink side because a frame having an unlearned source MAC address c2 added has arrived from the downlink side and, at the
10 same time, broadcasts the learning frame having the source tag address g2 added to the uplink side along the tree T2. As a result, the learning frame is transferred to both the node G3 and the node G4.

The node G4 receives from the uplink port the
15 main signal frame of the destination expansion tag g1 sent from the node G2. And, the output port is retrieved with the destination expansion tag g1 used as a key. Then, because the output port to the expansion forwarding tag g1 is always set to the root port side of
20 the spanning tree T1, the node G4 transfers the received frame from the uplink port to the node G1. At this time, no change is made to the frame. Therefore, no operation is made to add or remove a tag or to rewrite the MAC address.

25 The node G4 receives the learning frame sent by the node G2 from the uplink side and learns that the client C2 having the MAC address c2 is connected to the

downlink side of the node G2 having the expansion tag address g2. Thus, when a frame addressed to the c2 is received from the downlink side from then on, the expansion forwarding tag g2 is added to the frame so to transfer to the root port side of the tree T2. At the same time, the received learning frame is broadcasted to the uplink side along the tree T2. But, the tree T2 is interrupted at the node G4, resulting in no transfer of the learning frame from the node G4 to the next node.

5 The node G3 receives the learning frame which is sent by the node G2 from the uplink side and learns that the client C2 having the MAC address c2 is connected to the downlink side of the node G2 having the expansion tag address g2. Thus, when a frame addressed to the c2 is received from the downlink side from then on, the expansion forwarding tag g2 is added to the frame so to transfer to the root port side of the tree T2. At the same time, the received learning frame is broadcasted to the uplink side along the tree T2. As a result, the learning frame is transferred to the node G1.

15 The node G1 receives from the uplink port the main signal frame of the destination expansion tag g1 sent from the node G4. And, the address g1 indicated on the destination expansion tag is own address, so that this expansion tag is removed, and the output port on the downlink side is searched with the destination MAC c1 used as a key. Then, it is seen by the previous

learning operation that the node having the destination
MAC address c1 is connected to which port of the
downlink side. Therefore, the node G1 transfers the
frame to the downlink port to which the client C1 is
5 connected.

The node G1 receives the learning frame which is
sent by the node G3 from the uplink side and learns that
the client C2 having the MAC address c2 is connected to
the downlink side of the node G2 having the expansion
10 tag address g2. Thus, when the node G1 receives a frame
addressed to the c2 from the downlink side from then on,
it adds the expansion forwarding tag g2 to the frame to
transfer to the root port side of the tree T2. At the
same time, it broadcasts the received learning frame to
15 the uplink side along the tree T1. But, the tree T2 is
interrupted at the node G1, resulting in no transfer of
the learning frame from the node G1 to the next node.

The client C1 receives the main signal frame of
the destination MAC address c1 transferred by the node
20 G1 and gives the frame to an application or another
program because the destination MAC address matches own
MAC address c1. In this example, the frame is given to a
PING program in the basic software, and the result of a
PING command is shown.

25 Thus, the communication sequence between the
client C1 and the client C2 was described under the
condition that it is immediately after the start-up of

the network operation or it has passed a long time sufficient from the termination of previous communications between the client C1 and the client C2, and the MAC address c1 of the client C1 and the address g1 of the node to which the client C1 belongs and also the MAC address c2 of the client C2 and the address g2 of the node to which the client C2 belongs are not learned by each of the nodes G1 to G4.

Sequence N112 is a communication sequence between the client C1 and the client C2 when it has not passed a long time after the termination of the previous communications between the client C1 and the client C2, and the MAC address c1 of the client C1 and the address g1 of the node to which the client C1 belongs and also the MAC address c2 of the client C2 and the address g2 of the node to which the client C2 belongs have been learned by each of the nodes G1 to G4.

Here, an example in which the client C1 sends an ICMP ECHO REQUEST frame to the client C2 and the client C2 sends back an ICMP ECHO REPLY frame will be described.

First, the client C1 sends to the client C2 the ICMP ECHO REQUEST frame having destination MAC of c2 and the source MAC of c1. This frame will be called the main signal frame in the following description.

The node G1 receives the main signal frame from the downlink port. When a tag to be added and an output port are searched with the destination MAC used as a key,

it is seen by learning that it is advisable to add the expansion forwarding tag g2 to the frame of the destination MAC address c2 to transfer to the root port side of the tree T2. Therefore, the node G1 adds the expansion forwarding tag g2 to the frame and transfers to the node G3.

The node G3 receives from the uplink port the main signal frame of the destination expansion tag g2 sent by the node G1. And, the output port is searched with the destination expansion tag g2 used as a key. Then, the output port for the expansion forwarding tag g2 is always set to the root port side of the spanning tree T2, so that the node G3 transfers the received frame from the uplink port toward the node G2. At this time, no change is made on the frame. Therefore, a tag is not added or removed, and the MAC address is not rewritten.

The node G2 receives from the uplink port the main signal frame of the destination expansion tag g2 sent by the node G3. And, the address g2 indicated on the destination expansion tag is own address, so that the expansion tag is removed, and the output port on the downlink side is searched with the destination MAC c2 used as a key. Then, it is seen by the previous learning operation that the node having the destination MAC address c2 is connected to which port of the downlink side. Therefore, the node G2 transfers the frame to the

downlink port to which the client C2 is connected.

The client C2 receives the main signal frame of the destination MAC address c2 transferred by the node G2. This frame is given to an application or another program because the destination MAC address matches own MAC address c2.

In this example, the frame sent from the client C1 is determined to be the ICMP ECHO REQUEST, so that the basic software of the client C2 creates an ICMP ECHO REPLY frame having the destination MAC address c1 and the source MAC address c2 and sends to the node G2. This frame is called the main signal frame in the following description.

The node G2 receives the frame from the downlink port. When a tag to be added and an output port are searched with the destination MAC used as a key, it is seen that the expansion forwarding tag g1 is advisably added to the frame of the destination MAC address c1 to transfer to the root port side of the tree T1. Therefore, the node G2 adds the expansion forwarding tag g1 to the frame and transfers to the node G4.

The node G4 receives from the uplink port the main signal frame of the destination expansion tag g1 which is sent from the node G2. And, the output port is searched with the destination expansion tag g1 used as a key. Then, the output port to the expansion forwarding tag g1 is always set to the root port side of the

spanning tree T1, so that the node G4 transfers the received frame from the uplink port to the node G1. At this time, no change is made on the frame. Therefore, a tag is not added or removed, and the MAC address is not
5 rewritten.

The node G1 receives from the uplink port the main signal frame of the destination expansion tag g1 which is sent from the node G4. And, the address g1 indicated on the destination expansion tag is own
10 address, so that this expansion tag is removed, and the output port on the downlink side is searched with the destination MAC c1 used as a key. Then, it is seen by the previous learning operation that the node having the destination MAC address c1 is connected to which port of
15 the downlink side. Therefore, the node G1 transfers the frame to the downlink port to which the client C1 is connected.

The client C1 receives the main signal frame of the destination MAC address c1 which is transferred by
20 the node G1. This frame is given to an application or another program because the destination MAC address matches own MAC address c1. This frame is given to an application or another program. In this example, the frame is given to the PING program in the basic software,
25 and the result of the PING command is shown.

Thus, the communication sequence between the client C1 and the client C2 was described under the

condition that it has not passed a long time after the termination of previous communications between the client C1 and the client C2, and the MAC address c1 of the client C1 and the address g1 of the node to which the client C1 belongs and also the MAC address c2 of the client C2 and the address g2 of the node to which the client C2 belongs have been learned by each of the nodes G1 to G4.

Sequence N113 is a communication sequence between the client C1 and the client C2 when the MAC learning aging time which is previously set on a timer through an equipment control program has passed from the start of communications between the client C1 and the client C2 or from the start of the previous MAC learning aging but a TAG learning aging time which is previously set on a timer through the equipment control program has not passed.

In this case, the MAC address c1 of the client C1 and the MAC address c2 of the client C2 have been learned, but it is set to retransmit the learning frame, and the address g1 of the node to which the client C1 belongs and the address g2 of the node to which the client C2 belongs have been learned by each of the nodes G1 to G4 in the same way as the sequence N112.

Here, an example in which the client C1 sends an ICMP ECHO REQUEST frame to the client C2, and the client C2 sends back an ICMP ECHO REPLY frame will be described.

First, the client C1 sends an ICMP ECHO REQUEST frame which has a destination MAC of c2 and a source MAC of c1 to the client C2. This frame is called the main signal frame in the following description.

5 The node G1 receives the main signal frame from
the downlink port. When a tag to be added and an output
port are searched with the destination MAC used as a key,
it is seen from the learning that the expansion
forwarding tag g2 may be added to the frame of the
10 destination MAC address c2 to transfer to the root port
side of the tree T2. Therefore, the node G1 adds the
expansion forwarding tag g2 to the frame and transfers
to the node G3.

Because the frame which is added the source MAC
15 address c1 requiring retransmission of the learning
frame has arrived from the downlink side, the node G1
broadcasts the learning frame having the added source
tag address g1 to the uplink side along the tree T1. As
a result, the learning frame is transferred to both the
20 node G3 and the node G4.

The node G3 receives from the uplink port the main signal frame of the destination expansion tag g2 which is sent from the node G1. And, the output port is retrieved with the destination expansion tag g2 used as a key. Then, the node G3 transfers the received frame from the uplink port toward the node G2 because the output port to the expansion forwarding tag g2 is always

set to the root port side of the spanning tree T2. At this time, no change is added to the frame. Therefore, a tag is not added or removed, and the MAC address is not rewritten.

5 The node G3 receives the learning frame which is sent by the node G1 from the uplink side and relearns that the client C1 having the MAC address c1 is connected to the downlink side of the node G1 having the expansion tag address g1. This relearning prevents the
10 contents of learning on the client C1 from disappearing from the node G3 by aging. At the same time, the received learning frame is broadcasted to the uplink side along the tree T1. But, the tree T1 is interrupted at the node G3, resulting in no transfer of the learning
15 frame from the node G3 to the next node.

 The node G4 receives the learning frame sent by the node G1 from the uplink side and relearns that the client C1 having the MAC address c1 is connected to the downlink side of the node G1 having the expansion tag
20 address g1. This relearning prevents the contents of learning on the client C1 from disappearing from the node G3 by aging. At the same time, the received learning frame is broadcasted to the uplink side along the tree T1. As a result, the learning frame is
25 transferred to the node G2.

 The node G2 receives from the uplink port the main signal frame of the destination expansion tag g2

which is sent from the node G3. And, the address g2 indicated on the destination expansion tag is own address, so that the expansion tag is removed, and the output port on the downlink side is searched with the destination MAC c2 used as a key. Then, it is seen by the previous learning operation that the node having the destination MAC address c2 is connected to which port of the downlink side. Therefore, the node G2 transfers the frame to the downlink port to which the client C2 is connected.

The node G2 receives from the uplink side the learning frame sent by the node G4 and relearns that the client C1 having the MAC address c1 is connected to the downlink side of the node G1 having the expansion tag address g1. This relearning prevents the contents of learning on the client C1 from disappearing from the node G3 by aging. At the same time, the received learning frame is broadcasted to the uplink side along the tree T1. But, the tree T1 is interrupted at the node G2, resulting in no transfer of the learning frame from the node G2 to the next node.

The client C2 receives the main signal frame of the destination MAC address c2 transferred by the node G2. This frame is given to an application or another program because the destination MAC address matches own MAC address c2.

In this example, the frame sent from the client

C1 is determined to be the ICMP ECHO REQUEST, so that the basic software of the client C2 creates an ICMP ECHO REPLY frame of the destination MAC address c1 and the source MAC address c2 and sends to the node G2. This
5 frame is called the main signal frame in the following description.

The node G2 receives the frame from the downlink port. When a tag to be added and an output port are searched with the destination MAC used as a key, it is
10 seen that the expansion forwarding tag g1 may be added to the frame of the destination MAC address c1 to transfer to the root port side of the tree T1. Therefore, the node G2 adds the expansion forwarding tag g1 to the frame and transfer to the node G4.

15 Because the frame having the added source MAC address c2 requiring the retransmission of the learning frame has arrived from the downlink side, the node G2 broadcasts the learning frame having the source tag address g2 added to the uplink side along the tree T1.
20 As a result, the learning frame is transferred to both the node G3 and the node G4.

The node G4 receives from the uplink port the main signal frame of the destination expansion tag g1 sent from the node G2. And, the output port is retrieved
25 with the destination expansion tag g1 used as a key. Then, because the output port to the expansion forwarding tag g1 is always set to the root port side of

the spanning tree T1, the node G4 transfers the received frame from the uplink port toward the node G1. At this time, no change is made to the frame. Therefore, a tag is not added or removed, and the MAC address is not rewritten.

5 The node G4 receives the learning frame sent by the node G2 from the uplink side and relearns that the client C2 having the MAC address c2 is connected to the downlink side of the node G2 having the expansion tag address g2. This relearning prevents the contents of learning on the client C2 from disappearing from the node G4 by aging. At the same time, the received learning frame is broadcasted to the uplink side along the tree T2. But, the tree T2 is interrupted at the node G4, resulting in no transfer of the learning frame from the node G4 to the next node.

15 The node G3 receives the learning frame sent by the node G2 from the uplink side and relearns that the client C2 having the MAC address c2 is connected to the downlink side of the node G2 having the expansion tag address g2. This relearning prevents the contents of learning on the client C2 from disappearing from the node G3 by aging. At the same time, the received learning frame is broadcasted toward the uplink side along the tree T2. As a result, the learning frame is transferred to the node G1.

25 The node G1 receives from the uplink port the

main signal frame of the destination expansion tag g1 which is sent from the node G4. And, the address g1 indicated on the destination expansion tag is own address, so that this expansion tag is removed, and the
5 output port on the downlink side is searched with the destination MAC c1 used as a key. Then, it is seen by the previous learning operation that the node having the destination MAC address c1 is connected to which port of the downlink side. Therefore, the node G1 transfers the
10 frame to the downlink port to which the client C1 is connected.

The node G1 receives the learning frame sent by the node G3 from the uplink side and relearns that the client C2 having the MAC address c2 is connected to the
15 downlink side of the node G2 having the expansion tag address g2. This relearning prevents the contents of learning on the client C2 from disappearing from the node G1 by aging. And, at the same time, the received learning frame is broadcasted to the uplink side along
20 the tree T1. But, the tree T2 is interrupted at the node G1, resulting in no transfer of the learning frame from the node G1 to the next node.

The client C1 receives the main signal frame of the destination MAC address c1 which is transferred by
25 the node G1. This frame is given to an application or another program because the destination MAC address matches own MAC address c1. In this example, the frame

is given to the PING program in the basic software, and the result of the PING command is shown.

Thus, the communication sequence between the client C1 and the client C2 was described under the condition that MAC learning aging time previously set on a timer through the equipment control program has passed after the start of communications between the client C1 and the client C2 or the start of the previous MAC learning aging but the TAG learning aging time previously set on the timer through the equipment control program has not passed.

This learning frame retransmission operation is performed to prevent the contents of address learning of each relay node from disappearing by aging in an asymmetrical network. This operation makes it possible to send an asymmetrical main signal frame to the Ethernet while maintaining the learning information.

The node G4 in this operation example can be replaced with node E4 which has a simplified structure of the node G4. The simplified node E4 is different from the node G4 on the following four points: (1) not having the memory duplicate information 3013, (2) not having the MAC forwarding table memory 2043, (3) not having the learning management program 302 and the timer 306, and (4) not sending or receiving the learning frame.

Then, a second operation example of this embodiment will be described with reference to Fig. 39.

Fig. 39 is a sequence diagram showing the exchange of frames between the individual nodes and the clients when the client C1 sends PING REQUEST to client C3 and the client C3 sends back PING REPLY to the client C1. This is determined as operation example 2.

In the sequence of Fig. 39, when the node G1, the node G2 and the node G4 are the same as the nodes in the sequence of Fig. 38, the node G3 is replaced with node S3 which is an existing ordinary Ethernet switch.

The existing node S3 is different from the node G3 on three points: (1) not having the tag forwarding table memory 2041 and the tag forwarding table memory 70131 which is a table in its memory duplicate information 3013, (2) not inserting or removing the expansion tag to or from a particular destination MAC address, and (3) not sending or receiving the learning frame.

Sequence N121 is a communication sequence between the client C1 and the client C3, which is an operation immediately after the startup of a network operation or after a lapse of adequately long time after the termination of the previous communications between the client C1 and the client C3, and MAC address c1 of the client C1, address g1 of a node to which the client C1 belongs and MAC address c3 of the client C3 are not learned by each of the node G1, the node G2, the node S3 and the node G4. Her , an example shows that the client

C1 sends an ICMP ECHO REQUEST frame to the client C3,
and the client C3 replies back an ICMP ECHO REPLY frame.

5 First, the client C1 sends to the client C3 the
ICMP ECHO REQUEST frame having a destination MAC of c3
and a source MAC of c1. This frame will be referred to
as the main signal frame in the following description.

10 The node G1 receives the frame from the downlink
port. A tag to be added and an output port are searched
with the destination MAC used as a key, but the search
does not make a hit because the learning on the MAC
address c3 has not completed. Therefore, the node G1
broadcasts the main signal frame along the tree T0. At
this time, no operation is made to add or remove a tag
to or from the frame. As a result, the main signal frame
15 is transferred to both the node S3 and the node G4.

Because the frame which has an unlearned source
MAC c1 added has arrived from the downlink side, the
node G1 learns that the MAC address c1 is connected to
the port on the downlink side and also broadcasts the
20 learning frame with the source tag address g1 added to
the uplink side along the tree T1. As a result, the
learning frame is transferred to both the node S3 and
the node G4.

25 The node G4 receives from the uplink port the
main signal frame which is addressed to the destination
MAC c3 sent from the node G1. At this time, the frame
addressed to the destination MAC address c1 learns that

it is advisable to send to the uplink port to which the node G1 is connected. And, the output port is searched with the destination MAC c3 used as a key, but the search does not make a hit because the learning on the MAC address c3 has not completed. Therefore, the node G4 broadcasts the main signal frame to the tree T0 and the port on the downlink side. At this time, no operation is made to add or remove a tag to the frame. As a result, the main signal frame is transferred from the uplink port to the node G2 along the tree T0.

The node G4 receives the learning frame sent by the node G1 from the uplink side and learns that the client C1 having the MAC address c1 is connected to the downlink side of the node G1 having the expansion tag address g1. This learning upon the arrival of the learning frame takes precedence over the above-described learning upon arrival of the main signal frame. Thus, when a frame addressed to the c1 is received from the downlink side from then on, the expansion forwarding tag g1 is added to the frame so to transfer to the root port side of the tree T1. At the same time, the received learning frame is broadcasted to the uplink side along the tree T1. As a result, the learning frame is transferred to the node G2.

The node G2 receives from the uplink port the main signal frame addressed to the destination MAC c3 sent from the node G4. At this time, it is learned that

the frame addressed to the destination MAC address c1 may be sent to the uplink port to which the node G4 is connected. And, the output port is searched with the destination MAC c3 used as a key, but the search does not make a hit because the learning on the MAC address c3 has not completed. Therefore, the node G2 broadcasts the main signal frame to the tree T0 and the port on the downlink side. At this time, no operation is made to add or remove a tag to or from the frame. As a result, the main signal frame is transferred to the client C2 from the downlink port.

The node G2 receives the learning frame sent by the node G4 from the uplink side and learns that the client C1 having the MAC address c1 is connected to the downlink side of the node G1 having the expansion tag address g1. This learning upon the arrival of the learning frame takes precedence over the above-described learning upon the arrival of the main signal frame. Thus, when the frame addressed to the c1 is received from the downlink side from then on, the expansion forwarding tag g1 is added to the frame to transfer to the root port side of the tree T1. At the same time, the received learning frame is broadcasted to the uplink side along the tree T1. But, the tree T1 is interrupted at the node G2, resulting in no transfer of the learning frame from node G2 to the next node.

The client C2 receives the main signal frame of

the destination MAC c3 transferred by the node G2 but discards it because the destination MAC address does not match own MAC address c2.

5 The node S3 receives the main signal frame addressed to the destination MAC c3 sent from the node G1. At this time, it is learned that the frame addressed to the destination MAC address c1 may be sent to the port to which the node G1 is connected. And, the output port is searched with the destination MAC c3 used as a
10 key, but the search does not make a hit because the learning on the MAC address c3 has not completed. Therefore, the node S3 broadcasts the main signal frame to the tree T0 and the port on the downlink side. At this time, no operation is made to add or remove a tag
15 to or from the frame. As a result, the main signal frame is transferred from the downlink port to the client C3.

 The node S3 receives the learning frame sent by the node G1 from the uplink side and broadcasts the received learning frame to the uplink side along the
20 tree T1. But, the tree T1 is interrupted at the node S3, resulting in no transfer of the learning frame from the node S3 to the next node.

 The node S3 can receive the learning frame to transfer the frame by the network control program 304
25 but cannot update table information by the learning management program 302 according to the contents of the received frame. Therefore, it cannot be learnt from the

learning frame that the client C1 having the MAC address c1 is connected to the downlink side of the node G1 having the expansion tag address g1.

5 The client C3 receives the main signal frame of the destination MAC address c3 transferred by the node S3. Because the destination MAC address matches own MAC address c3, this frame is given to an application or another program.

10 In this example, the frame sent from the client C1 is determined to be the ICMP ECHO REQUEST, so that basic software of the client C3 creates an ICMP ECHO REPLY frame of the destination MAC address c1 and the source MAC address c3 to send to the node S3. This frame is referred to as the main signal frame in the following
15 description.

 The node S3 receives the main signal frame sent from the client C3. At this time, it is learned that the frame addressed to the destination MAC address c3 may be sent to the port on the side to which the client C3 is
20 connected. And, when the output port is searched with the destination MAC used as a key, it is seen by the previous learning operation that the frame addressed to the destination MAC address c1 may be transferred to a port to which the node G1 is connected. Therefore, the
25 node S3 transfers the frame to the node G1.

 The node G1 receives the main signal frame transferred by the node S3. At this time, it is learned

that the frame addressed to the destination MAC address c3 may be sent to a port on the side to which the node S3 is connected. And, when the output port is searched with the destination MAC used as a key, it is seen by
5 the previous learning operation that the frame addressed to the destination MAC address c1 may be transferred to the downlink port on the side to which the client C1 is connected. Therefore, the node G1 transfers the frame to the client C1.

10 The client C1 receives the main signal frame of the destination MAC address c1 transferred by the node G1. Because the destination MAC address matches own MAC address c1, this frame is given to an application or another program. In this example, the frame is given to
15 the PING program in the basic software, and a result of the PING command is shown.

Thus, the communication sequence between the client C1 and the client C3 was described under the condition that it is immediately after the start-up of
20 the network operation or it has passed a long time sufficient from the termination of previous communications between the client C1 and the client C3, and the MAC address c1 of the client C1, the address g1 of the node to which the client C1 belongs and also the
25 MAC address c3 of the client C3 are not learned by each of the node G1, the node G2, the node S3 and the node G4.

Sequence N122 is a communication sequence between

the client C1 and the client C3 when it has not passed a long time after the termination of the previous communications between the client C1 and the client C3, and the MAC address c1 of the client C1 and the address g1 of the node to which the client C1 belongs have been learned by each of the node G1, the node G2, the node S3 and the node G4 and also the MAC address c3 of the client C3 has been learned at each of the node G1 and the node S3.

Here, an example in which the client C1 sends an ICMP ECHO REQUEST frame to the client C3, and the client C3 replies back an ICMP ECHO REPLY frame will be described.

First, the client C1 sends the client C3 the ICMP ECHO REQUEST frame having a destination MAC of c3 and a source MAC of c1. This frame is referred to as the main signal frame in the following description.

The node G1 receives the main signal frame from the downlink port. When a tag to be added and an output port are searched with the destination MAC used as a key, it is seen by learning that the frame of the destination MAC address c3 may be transferred to the port on side of the node S3 without adding the expansion forwarding tag. Therefore, the node G1 is transferred as it is to the uplink port to which the node S3 is connected without performing an operation to add or remove a tag to or from the frame. At this time, it is learned that the

frame addressed to the destination MAC address c1 may be sent to the downlink port on the side to which the client C1 is connected.

5 The node S3 receives the main signal frame sent from the node G1. At this time, it is relearned that the frame addressed to the destination MAC address c1 may be sent to the port on the side to which the node G1 is connected. And, when the output port is searched with the destination MAC used as a key, it is seen by
10 learning that the frame addressed to the destination MAC address c3 may be transferred to the port to which the client C3 is connected. Therefore, the node S3 transfers the frame to the port on the side to which the client C3 is connected.

15 The client C3 receives the main signal frame of the destination MAC address c3 which is transferred by the node S3. Because the destination MAC address matches own MAC address c3, this frame is given to an application or another program.

20 In this example, the frame sent from the client C1 is determined to be the ICMP ECHO REQUEST, so that the basic software of the client C3 creates an ICMP ECHO REPLY frame of the destination MAC address c1 and the source MAC address c3 and sends to the node S3. This
25 frame is referred to as the main signal frame in the following description.

 The node S3 receives the main signal frame sent

from the client C3. At this time, it is relearned that the frame addressed to the destination MAC address c3 may be sent to the port on the side to which the client C3 is connected. And, when the output port is searched with the destination MAC used as a key, it is seen by the previous learning operation that the frame addressed to the destination MAC address c1 may be transferred to the port to which the node G1 is connected. Therefore, the node S3 transfers the frame to the node G1.

The node G1 receives the main signal frame transferred by the node S3. At this time, it is relearned that the frame addressed to the destination MAC address c3 may be sent to the uplink port on the side to which the node S3 is connected. And, when the output port is searched with the destination MAC address as a key, it is seen by the previous learning operation that the frame addressed to the destination MAC address c1 may be transferred to the downlink port on the side to which the client C1 is connected. Therefore, the node G1 transfers the frame to the client C1.

The client C1 receives the main signal frame of the destination MAC address c1 which is transferred by the node G1. Because the destination MAC address matches own MAC address c1, the frame is given to an application or another program. In this example, the frame is given to the PING program in the basic software, and the result of the PING command is shown.

Thus, the communication sequence between the client C1 and the client C3 was described under the condition that a long time has not passed after the termination of the previous communications between the client C1 and the client C3, and the MAC address c1 of the client C1 and the address g1 of the node to which the client C1 belongs have been learned by each of the node G1, the node G2, the node S3 and the node G4 and also the MAC address c3 of the client C3 has been learned by each of the node G1 and the node S3.

Sequence N123 is a communication sequence between the client C1 and the client C3 when MAC learning aging time which is previously set on a timer through an equipment control program has passed from the start of communications between the client C1 and the client C3 or from the start of the previous MAC learning aging but TAG learning aging time which is previously set on the timer through the equipment control program has not passed.

In this case, the MAC address c1 of the client C1 and the MAC address c3 of the client C3 have been learned but set to retransmit the learning frame, and the address g1 of the node to which the client C1 belongs has been learned by each of the node G1, the node G2, the node S3 and the node G4 in the same way as the sequence N122.

Here, an example in which the client C1 sends an

ICMP ECHO REQUEST frame to the client C3, and the client C3 replies back an ICMP ECHO REPLY frame will be described.

5 First, the client C1 sends to the client C3 the ICMP ECHO REQUEST frame having a destination MAC of c3 and a source MAC of c1. This frame is referred to as the main signal frame in the following description.

10 The node G1 receives the main signal frame from the downlink port. When a tag to be added and an output port are searched with the destination MAC used as a key, it is seen by learning that the frame of the destination MAC address c3 may be transferred to the port on the side of the node S3 without adding the expansion forwarding tag. Therefore, the node G1 is transferred as
15 it is to the uplink port to which the node S3 is connected without performing an operation to add or remove the tag to or from the frame. At this time, it is relearned that the frame addressed to the destination MAC address c1 may be sent to the downlink port on the
20 side to which the client C1 is connected.

Because the frame with the source MAC address c1 requiring the retransmission of the learning frame has arrived from the downlink side, the node G1 broadcasts the learning frame having the added source tag address
25 g1 to the uplink side along the tree T1. As a result, the learning frame is transferred to both the node S3 and the node G4.

The node G4 receives the learning frame which is sent by the node G1 from the uplink side and relearns that the client C1 having the MAC address c1 is connected to the downlink side of the node G1 having the expansion tag address g1. This relearning prevents the contents of learning on the client C1 from disappearing from the node G3 by aging. And, at the same time, the received learning frame is broadcasted to the uplink side along the tree T1. As a result, the learning frame is transferred to the node G2.

The node G2 receives the learning frame which is sent by the node G4 from the uplink side and relearns that the client C1 having the MAC address c1 is connected to the downlink side of the node G1 having the expansion tag address g1. This relearning prevents the contents of learning on the client C1 from disappearing from the node G3 by aging. At the same time, the received learning frame is broadcasted to the uplink side along the tree T1. But, because the tree T1 is interrupted at the node G2, the learning frame is not transferred from the node G2 to the next node as a result.

The node S3 receives the main signal frame which is sent from the node G1. At this time, it is relearned that the frame addressed to the destination MAC address c1 may be sent to the port on the side to which the node G1 is connected. And, when the output port is retrieved

with the destination MAC used as a key, it is seen by learning that the frame addressed to the destination MAC address c3 may be transferred to the port to which the client C3 is connected. Therefore, the node S3 transfers
5 the frame to the port on the side to which the client C3 is connected.

The node S3 receives the learning frame which is sent by the node G1 from the uplink side and broadcasts the received learning frame to the uplink side along the
10 tree T1. But, the tree T1 is interrupted at the node S3, so that the learning frame is not transferred from the node S3 to the next node as a result.

The client C3 receives the main signal frame of the destination MAC address c3 which is transferred by
15 the node S3. Because the destination MAC address matches own MAC address c3, this frame is given to an application or another program.

In this example, the frame sent from the client C1 is determined to be the ICMP ECHO REQUEST, so that
20 the basic software of the client C3 creates an ICMP ECHO REPLY frame of the destination MAC address c1 and the source MAC address c3 and sends to the node S3. This frame is referred to as the main signal frame in the following description.

25 The node S3 receives the main signal frame which is sent from the client C3. At this time, it is relearned that the frame addressed to the destination

MAC address c3 may be sent to the port on the side to which the client C3 is connected. And, when the output port is searched with the destination MAC used as a key, it is seen from the previous learning operation that the frame addressed to the destination MAC address c1 may be transferred to the port to which the node G1 is connected. Therefore, the node S3 transfers the frame to the node G1.

The node G1 receives the main signal frame which is transferred by the node S3. At this time, it is relearned that the frame addressed to the destination MAC address c3 may be sent to the uplink port on the side to which the node S3 is connected. And, when the output port is searched with the destination MAC used as a key, it is seen by the previous learning operation that the frame addressed to the destination MAC address c1 may be transferred to the downlink port on the side to which the client C1 is connected. Therefore, the node G1 transfers the frame to the client C1.

The client C1 receives the main signal frame of the destination MAC address c1 which is transferred by the node G1. Because the destination MAC address matches own MAC address c1, this frame is given to an application or another program. In this example, the frame is given to the PING program in the basic software, and the result of the PING command is shown.

Thus, the communication sequence between the

client C1 and the client C3 was described under the condition that the MAC learning aging time previously set on a timer through the equipment control program has passed after the start of communications between the client C1 and the client C3 or the start of the previous MAC learning aging but the TAG learning aging time previously set on the timer through the equipment control program has not passed.

The node G4 in this operation example can be replaced with node E4 which has a simplified structure of the node G4. The simplified node E4 is different from the node G4 on the following four points: (1) not having the memory duplicate information 3013, (2) not having the MAC forwarding table memory 2043, (3) not having the learning management program 302 and the timer 306, and (4) not sending or receiving the learning frame.

Then, a third operation example of this embodiment will be described with reference to Fig. 40.

Fig. 40 is a sequence diagram showing the exchange of frames between the individual nodes and the clients when the client C3 sends PING REQUEST to the client C1 and the client C1 sends back PING REPLY to the client C3. This is determined as operation example 3.

In the sequence of Fig. 40, when the node G1, the node G2 and the node G4 are the same as those of the sequence shown in Fig. 38, the node G3 may be replaced with node S3 which is an ordinary Ethernet switch.

The existing node S3 is different from the node G3 on the following three points: (1) not having the tag forwarding table memory 2041 and the tag forwarding table memory 70131 which is a table in its memory
5 duplicate information 3013, (2) not inserting or removing the expansion tag to or from a particular destination MAC address, and (3) not sending or receiving a learning frame.

Sequence N131 is a communication sequence between
10 the client C3 and the client C1 which is an operation immediately after the startup of a network operation or after a lapse of adequately long time after the termination of the previous communications between the client C3 and the client C1, and the MAC address c1 of
15 the client C1, the address g1 of node to which the client C1 belongs and the MAC address c3 of client C3 are not learned by each of the node G1, the node G2, the node S3 and the node G4. Here, an example shows that the client C3 sends the ICMP ECHO REQUEST frame to the
20 client C1, and the client C1 replies back the ICMP ECHO REPLY frame.

First, the client C3 sends to the client C1 ICMP ECHO REQUEST frame having the destination MAC of c1 and the source MAC of c3. This frame will be referred to as
25 the main signal frame in the following description.

The node S3 receives the main signal frame addressed to the destination MAC c1 which is sent by the

client C3. At this time, it is learned that the frame addressed to the destination MAC address c3 may be sent to the port to which the client C3 is connected. And, the output port is searched with the destination MAC c1 used as a key. But, the search does not make a hit because the learning on the MAC address c1 has not completed. Therefore, the node S3 broadcasts the main signal frame to the tree T0 and the port on the downlink side. At this time, no operation is made to add or remove the tag to or from the frame. As a result, the main signal frame is transferred to the node G1.

The node G1 receives the frame from the uplink port. A tag to be added and an output port are searched with the destination MAC c1 used as a key, but the search does not make a hit because the learning on the MAC address c1 has not completed. Therefore, the node G1 broadcasts the main signal frame to the tree T0 and the downlink port. At this time, no operation is made to add or remove a tag to or from the frame. As a result, the main signal frame is transferred to both the client C1 and the node G4.

The node G4 receives from the uplink port the main signal frame addressed to the destination MAC c1 which is sent by the node G1. At this time, it is learned that the frame addressed to the destination MAC address c3 may be sent to the uplink port to which the node G1 is connected. And, the output port is searched

with the destination MAC c1 used as a key, but the search does not make a hit because the learning on the MAC address c1 has not completed. Therefore, the node G4 broadcasts the main signal frame to the tree T0 and the port on the downlink side. At this time, no operation is made to add or remove the tag to or from the frame. As a result, the main signal frame is transferred from the uplink port to the node G2 along the tree T0.

The node G2 receives from the uplink port the main signal frame addressed to the destination MAC c1 which is sent by the node G4. At this time, it is learned that the frame addressed to the destination MAC address c3 may be sent to the uplink port to which the node G4 is connected. And, the output port is searched with the destination MAC c1 used as a key. But, because the learning on the MAC address c1 has not completed, the search does not make a hit. Therefore, the node G2 broadcasts the main signal frame to the tree T0 and the port on the downlink side. At this time, no operation is made to add or remove the tag to or from the frame. As a result, the main signal frame is transferred from the downlink port to the client C2.

The client C2 receives the main signal frame of the destination MAC c1 which is transferred by the node G2, but because the destination MAC address does not match own MAC address c2, this frame is discarded.

The client C1 receives the main signal frame of

the destination MAC address c1 which is transferred by the node G1. Because the destination MAC address matches own MAC address c1, this frame is given to an application or another program.

5 In this example, the frame sent from the client C3 is determined to be the ICMP ECHO REQUEST, so that the basic software of the client C1 creates an ICMP ECHO REPLY frame of the destination MAC address c3 and the source MAC address c1 and sends to the node G1. This
10 frame is referred to as the main signal frame in the following description.

 The node G1 receives the main signal frame from the downlink port. When a tag to be added and an output port are searched with the destination MAC used as a key,
15 it is seen from the learning that the frame of the destination MAC address c3 may be transferred to the port on the side of the node S3 without adding the expansion forwarding tag. Therefore, the node G1 does not make an operation to add or remove a tag to or from
20 the frame but transfers to the uplink port to which the node S3 is connected.

 Because a frame having an unlearned source MAC c1 added has arrived from the downlink side, the node G1 learns that the MAC address c1 is connected to the port
25 on the downlink side and also broadcasts the learning frame having the source tag address g1 added to the uplink side along the tree T1. As a result, the learning

frame is transferred to both the node S3 and the node G4.

5 The node G4 receives the learning frame which is
sent by the node G1 from the uplink side and learns that
the client C1 having the MAC address c1 is connected to
the downlink side of the node G1 having the expansion
tag address g1. Thus, when a frame addressed to the c1
is received from the downlink side from then on, the
expansion forwarding tag g1 is added to the frame, which
is then transferred to the root port side of the tree T1.
10 And, at the same time, the received learning frame is
broadcasted to the uplink side along the tree T1. As a
result, the learning frame is transferred to the node G2.

15 The node G2 receives the learning frame which is
sent by the node G4 from the uplink side and learns that
the client C1 having the MAC address c1 is connected to
the downlink side of the node G1 having the expansion
tag address g1. Thus, when the frame addressed to the c1
is received from the downlink side from then on, the
expansion forwarding tag g1 is added to the frame, which
20 is then transferred to the root port side of the tree T1.
At the same time, the received learning frame is
broadcasted to the uplink side along the tree T1. But,
because the tree T1 is interrupted at the node G2, the
learning frame is not transferred from the node G2 to
25 the next node as a result.

 The node S3 receives the main signal frame
addressed to the destination MAC c3 which is sent from

the node G1. At this time, it is learned that the frame addressed to the destination MAC address c1 may be sent to the port to which the node G1 is connected. And, when the output port is searched with the destination MAC used as a key, it is seen by the previous learning operation that the frame addressed to the destination MAC address c3 may be transferred to the port to which the client C3 is connected. Therefore, the node S3 transfers the frame to the client C3.

10 The node S3 receives the learning frame which is sent by the node G1 from the uplink side and broadcasts the received learning frame to the uplink side along the tree T1. But, because the tree T1 is interrupted at the node S3, the learning frame is not transferred from the node S3 to the next node as a result.

15 The node S3 can receive the learning frame to transfer it by the network control program 304 but cannot use the contents of the received frame to update the table information by the learning management program 302. Therefore, it cannot be learned by the learning frame that the client C1 having the MAC address c1 is connected to the downlink side of the node G1 having the expansion tag address g1.

20 The client C3 receives the main signal frame of the destination MAC address c3 which is transferred by the node S3. Because the destination MAC address matches own MAC address c3, this frame is given to an

application or another program. In this example, the frame is given to the PING program in the basic software, and the result of the PING command is shown as a result.

Thus, the communication sequence between the client C3 and the client C1 was described under the condition that it is immediately after the start-up of the network operation or after a lapse of sufficiently long time from the termination of the previous communications between the client C3 and the client C1, and the MAC address c1 of the client C1 and the address g1 of the node to which the client C1 belongs and also the MAC address c3 of the client C3 are not learned by each of the node G1, the node G2, the node S3 and the node G4.

Sequence N132 is a communication sequence between the client C3 and the client C1 under the conditions that a long time has not passed after the termination of the previous communications between the client C3 and the client C1, the MAC address c1 of the client C1 and the address g1 of the node to which the client C1 belongs have been learned by each of the node G1, the node G2, the node S3 and the node G4, and also the MAC address c3 of the client C3 has been learned by each of the node G1 and the node S3.

Here, an example shows that the client C3 sends the ICMP ECHO REQUEST frame to the client C1, and the client C1 replies back the ICMP ECHO REPLY frame.

First, the client C3 sends to the client C1 the ICMP ECHO REQUEST frame having the destination MAC of c1 and the source MAC of c3. This frame will be referred to as the main signal frame in the following description.

5 The node S3 receives the main signal frame which is sent from the client C3. At this time, it is relearned that the frame addressed to the destination MAC address c3 may be sent to the port on the side to which the client C3 is connected. And, when the output
10 port is searched with the destination MAC used as a key, it is seen by the previous learning operation that the frame addressed to the destination MAC address c1 may be transferred to the port to which the node G1 is
15 connected. Therefore, the node S3 transfers the frame to the node G1.

 The node G1 receives the main signal frame which is transferred by the node S3. At this time, it is relearned that the frame addressed to the destination
20 MAC address c3 may be sent to the uplink port on the side to which the node S3 is connected. And, when the output port is searched with the destination MAC used as
25 a key, it is seen by the previous learning operation that the frame addressed to the destination MAC address c1 may be transferred to the downlink port on the side
to which the client C1 is connected. Therefore, the node G1 transfers the frame to the client C1.

 The client C1 receives the main signal frame of

the destination MAC address c1 which is transferred by the node G1. Because the destination MAC address matches own MAC address c1, this frame is given to an application or another program.

5 In this example, because the frame sent from the client C3 is determined as ICMP ECHO REQUEST, the basic software of the client C1 creates ICMP ECHO REPLY frame of the destination MAC address c3 and the source MAC address c1 and sends to the node G1. This frame will be
10 referred to as the main signal frame in the following description.

 The node G1 receives the main signal frame from the downlink port. When a tag to be added and an output port are searched with the destination MAC used as a key,
15 it is seen from the learning that the frame of the destination MAC address c3 may be transferred to the port on the node S3 side without adding the expansion forwarding tag. Therefore, the node G1 is transferred as it is to the uplink port to which the node S3 is
20 connected without performing an operation to add or remove the tag to or from the frame. At this time, it is relearned that the frame addressed to the destination MAC address c1 may be sent to the downlink port on the side to which the client C1 is connected.

25 The node S3 receives the main signal frame which is sent from the node G1. At this time, it is relearned that the frame addressed to the destination MAC address

c1 may be sent to the port on the side to which the node G1 is connected. And, when the output port is searched with the destination MAC used as a key, it is seen by the learning that the frame addressed to the destination
5 MAC address c3 may be transferred to the port to which the client C3 is connected. Therefore, the node S3 transfers the frame to the port on the side to which the client C3 is connected.

10 The client C3 receives the main signal frame of the destination MAC address c3 which is transferred by the node S3. Because the destination MAC address matches own MAC address c3, this frame is given to an application or another program. In this example, the frame is given to the PING program in the basic software,
15 and the result of the PING command is shown.

Thus, the communication sequence between the client C3 and the client C1 was described under the conditions that a long time has not passed after the termination of the previous communications between the
20 client C3 and the client C1, the MAC address c1 of the client C1 and the address g1 of the node to which the client C1 belongs have been learned by each of the node G1, the node G2, the node S3 and the node G4 and also the MAC address c3 of the client C3 has been learned by
25 each of the node G1 and the node S3.

Sequence N133 is a communication sequence between the client C3 and the client C1 under the conditions

that the MAC learning aging time previously set on a timer through the equipment control program has passed after the start-up of the communications between the client C3 and the client C1 or the start-up of the previous MAC learning aging but the TAG learning aging time previously set on the timer through the equipment control program has not passed.

5 In this case, the MAC address c1 of the client C1 and the MAC address c3 of the client C3 have been learned but are set to retransmit the learning frame, 10 the address g1 of the node to which the client C1 belongs has been learned by each of the node G1, the node G2, the node S3 and the node G4 in the same way as the sequence N122.

15 Here, an example shows that the client C3 sends the ICMP ECHO REQUEST frame to the client C1, and the client C1 replies back the ICMP ECHO REPLY frame.

First, the client C3 sends to the client C1 the ICMP ECHO REQUEST frame having the destination MAC of c1 and the source MAC of c3. This frame will be referred to 20 as the main signal frame in the following description.

The node S3 receives the main signal frame which is sent from the client C3. At this time, it is relearned that the frame addressed to the destination 25 MAC address c3 may be sent to the port on the side to which the client C3 is connected. And, when the output port is searched with the destination MAC used as a key,

it is learned from the previous learning operation that the frame addressed to the destination MAC address c1 may be transferred to the port to which the node G1 is connected. Therefore, the node S3 transfers the frame to
5 the node G1.

The node G1 receives the main signal frame which is transferred by the node S3. At this time, it is relearned that the frame addressed to the destination MAC address c3 may be sent to the uplink port on the
10 side to which the node S3 is connected. And, when the output port is searched with the destination MAC used as a key, it is seen from the previous learning operation that the frame addressed to the destination MAC address c1 may be transferred to the downlink port on the side
15 to which the client C1 is connected. Therefore, the node G1 transfers the frame to the client C1.

The client C1 receives the main signal frame of the destination MAC address c1 which is transferred by the node G1. Because the destination MAC address matches
20 own MAC address c1, this frame is given to an application or another program.

In this example, the frame sent from the client C3 is determined as the ICMP ECHO REQUEST, so that the basic software of the client C1 creates an ICMP ECHO
25 REPLY frame of the destination MAC address c3 and the source MAC address c1 and sends to the node G1. This frame is referred to as the main signal frame in the

following description.

The node G1 receives the main signal frame from the downlink port. When a tag to be added and an output port are searched with the destination MAC used as a key,
5 it is seen from the learning that the frame of the destination MAC address c3 may be transferred to the port on the node S3 side without adding the expansion forwarding tag. Therefore, the node G1 transfers the frame as it is to the uplink port to which the node S3
10 is connected without performing an operation to add or remove the tag to or from the frame.

Because a frame which is added the source MAC address c1 requiring the retransmission of the learning frame has arrived from the downlink side, the node G1
15 broadcasts the learning frame having the source tag address g1 added to the uplink side along the tree T1. As a result, the learning frame is transferred to both the node S3 and the node G4.

The node G4 receives the learning frame which is
20 sent by the node G1 from the uplink side and relearns that the client C1 having the MAC address c1 is connected to the downlink side of the node G1 having the expansion tag address g1. Thus, when the frame addressed to the c1 is received from the downlink side from then
25 on, the expansion forwarding tag g1 is added to the frame to transfer to the root port side of the tree T1. At the same time, the received learning frame is

broadcasted to the uplink side along the tree T1. As a result, the learning frame is transferred to the node G2.

5 The node G2 receives the learning frame which is sent by the node G4 from the uplink side and relearns that the client C1 having the MAC address c1 is connected to the downlink side of the node G1 having the expansion tag address g1. Thus, when a frame addressed to the c1 is received from the downlink side from then on, the expansion forwarding tag g1 is added to the frame to transfer to the root port side of the tree T1. At the same time, the received learning frame is broadcasted to the uplink side along the tree T1. But, the tree T1 is interrupted at the node G2, resulting in no transfer of the learning frame from the node G2 to the next node.

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 The node S3 receives the main signal frame addressed to the destination MAC c3 which is sent from the node G1. At this time, it is relearned that the frame addressed to the destination MAC address c1 may be sent to the port to which the node G1 is connected. And, when the output port is searched with the destination MAC used as a key, it is seen from the previous learning operation that the frame addressed to the destination MAC address c3 may be transferred to the port to which the client C3 is connected. Therefore, the node S3 transfers the frame to the client C3.

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 The node S3 receives the learning frame sent by

the node G1 from the uplink side and broadcasts the received learning frame to the uplink side along the tree T1. But, because the tree T1 is interrupted at the node S3, the learning frame is not transferred from the
5 node S3 to the next node as a result.

The client C3 receives the main signal frame of the destination MAC address c3 transferred by the node S3. Because the destination MAC address matches own MAC address c3, this frame is given to an application or
10 another program. In this example, the frame is given to the PING program in the basic software, and the result of the PING command is shown.

Thus, the communication sequence between the client C3 and the client C1 was described under the
15 condition that the MAC learning aging time previously set on a timer through the equipment control program has passed from the start-up of the communications between the client C3 and the client C1 or the start-up of the previous MAC learning aging but the TAG learning aging
20 time previously set on the timer through the equipment control program has not passed.

The node G4 in this operation example can be replaced with node E4 which has a simplified structure of the node G4. The simplified node E4 is different from
25 the node G4 on the following four points: (1) not having the memory duplicate information 3013, (2) not having the MAC forwarding table memory 2043, (3) not having the

learning management program 302 and the timer 306, and
(4) not sending or receiving the learning frame.

Then, the effects of the embodiment will be
described.

5 Conventionally, when an asymmetrical flow which
has a different node where the flow passes depending on
a direction is flown on a network according to the
Ethernet, a learning process does not function, a frame
reaches the destination but it is also transmitted to
10 unnecessary destinations. Therefore, there were problems
that the network became congestion and bandwidth
usability became low.

 In this embodiment, even when the asymmetrical
flow is flown by sending the learning frame through a
15 path opposite to the path where the main signal frame
flows, the learning process can be functioned, the
network congestion can be remedied from becoming
congestion, and the bandwidth usability can be improved.

 Conventionally, when a frame having a tag
20 indicating a destination was transferred, it was
necessary to previously set an expansion tag (forwarding
tag) to be added for each node according to the
destination MAC address.

 In this embodiment, the expansion tag to be added
25 to each node according to the destination MAC address
can be set by containing tag information in the learning
frame, and the setting operation can be automated.

The present invention was described above with reference to the preferable embodiment and examples, but the invention is not limited to such embodiments and examples but can be practiced in various modified modes
5 without departing from the spirit and scope of its technical idea.

As described above, the following effects can be achieved by the present invention.

First, the network congestion can be remedied,
10 and the bandwidth usability can be improved.

It is because, even if the asymmetrical flow is flown, the learning process can be operated by sending the learning frame through the path opposite to the path in which the main signal frame flows.

15 Second, the setting of the forwarding tag to be added can be automated.

It is because, the tag information is included in the learning frame.

Although the invention has been illustrated and
20 described with respect to exemplary embodiment thereof, it should be understood by those skilled in the art that the foregoing and various other changes, omissions and additions may be made therein and thereto, without departing from the spirit and scope of the present
25 invention. Therefore, the present invention should not be understood as limited to the specific embodiment set out above but to include all possible embodiments which

can be embodied within a scope encompassed and
equivalents thereof with respect to the feature set out
in the appended claims.